HILGARDIA

A Journal of Agricultural Science Published by the California Agricultural Experiment Station

VOLUME 20 OCTOBER, 1950 NUMBER 15

APHID TRANSMISSION OF A MOSAIC VIRUS AND SYMPTOMS OF OTHER VIRUS DISEASES OF PRIMULA OBCONICA

HENRY H. P. SEVERIN and C. M. TOMPKINS

UNIVERSITY OF CALIFORNIA · BERKELEY, CALIFORNIA

CONTENTS

H I L G A R D I A

A Journal of Agricultural Science Published by the California Agricultural Experiment Station

VOL. 20 OCTOBER, 1950 No. 15

APHID TRANSMISSION OF A MOSAIC VIRUS AND SYMPTOMS OF OTHER VIRUS DISEASES OF PRIMULA OBCONICA[1]

HENRY H. P. SEVERIN[2] and C. M. TOMPKINS[3]

PRIMULA OBCONICA is a popular, attractive, ornamental potting plant which has commonly been found to be infected with a mosaic disease in commercial greenhouses in San Francisco. The losses of infected seedling plants have ranged from 5 to 25 per cent.

A study was undertaken on aphid transmission of the mosaic virus of *Primula obconica*. Tests were made both with species of aphids that breed on this host plant in the greenhouse, and with species that do not. Other aspects investigated include the efficiency in the transmission of the virus by single unfasted, infective aphids. A comparison was made of the transmission of the virus by lots of 20 unfasted, infective aphids with lots of 20 fasted aphids in short infection-feeding periods on a diseased plant.

A comparison was made of the symptoms of *P. obconica* mosaic with those of common-cucumber, celery-calico, and western-cucumber-mosaic viruses. An attempt was made to experimentally infect *P. obconica* with the ordinary-tobacco-mosaic virus. Tests were made on the susceptibility of this species of *Primula* to the California-aster-yellows and spotted-wilt viruses.

REVIEW OF LITERATURE

Tompkins and Middleton (1941)[4] reviewed the literature on mosaic diseases of *Primula* species, and reported the experimental host range and properties of a mosaic virus of *P. obconica*. Since the publication of that paper, other references to virus diseases affecting the genus have appeared in the literature.

Moore (1947) lists a mosaic of *Primula* in his report on diseases of crops in England.

P. obconica was found (Smith, 1947) to be susceptible to attack by several viruses, including cucumber mosaic, tomato black ring, and tomato bushy

[1] Received for publication August 29, 1949.

[2] Entomologist in the Experiment Station, Berkeley.

[3] Associate Plant Pathologist in the Experiment Station, Berkeley.

[4] See "Literature Cited" for citations referred to in text by author and date.

stunt, of which the first was the most important. The cucumber-mosaic virus reportedly causes mottling and stunting in both *P. obconica* and *P. sinensis;* while the color of the flowers is affected and flecks or streaks develop on the petals. Experimental infection of *P. obconica* by the tomato-bushy-stunt virus induced a severe systemic necrosis. Plants were distorted and stunted, while flowers, few in number and malformed, failed to open.

P. obconica is stated to be a host to not less than 11 viruses (Kristensen, 1949).

Additional references to publications on specific virus diseases of *Primula* will be found in the ensuing sections.

SOURCES OF VIRUSES

Naturally infected *P. obconica* seedling plants were collected in a greenhouse in San Francisco, California (Tompkins and Middleton, 1941). The original source of the western-cucumber-mosaic virus was an infected Honey Dew melon (*Cucumis melo* var. *inodorus*) collected on November 7, 1932, at Keyes in the San Joaquin Valley. Common-cucumber-mosaic and ordinary-tobacco-mosaic viruses were kindly sent to us by James Johnson, University of Wisconsin. Celery-calico virus was obtained from naturally infected celery (*Apium graveolens* var. *dulce*) in the Santa Clara Valley in 1933. Celery infected with California aster-yellows virus was first collected in the San Joaquin Valley in 1925. The spotted-wilt virus was obtained from naturally infected pink and white calla plants (*Zantedeschia rehmannii* and *Z. aethiopica*) grown from flowering-sized corms in pots in the greenhouse.

A MOSAIC DISEASE OF PRIMULA OBCONICA

Symptomatology

The first symptom, which occasionally occurs on the youngest leaf, is a clearing of the veins and veinlets 18 to 26 days after inoculation (plate 2, *A*). This is followed by a systemic yellow-green mottle (plate 3, *A*) consisting of irregular, dark-green blisterlike elevations (plate 3, *B, C*) or flat, dark-green islands (plate 3, *D*) and upward-curling or cupping of the younger leaves. In the advanced stage of the disease, the outer leaves may show large chlorotic and dark-green areas (plate 3, *E*). Malformations of the leaves occur, and occasionally a filiform or shoestring effect is induced at the tip of the leaves (plate 3, *F*), resembling somewhat the symptoms produced by cucumber-mosaic or tobacco-mosaic viruses on some host plants. Breaking in color of the petals occurs (plate 1, *A*) and the calyx is mottled. Infected plants are stunted and the leaves, petioles, flowers and peduncles are reduced in size.

Feeding by the noninfective foxglove aphid, *Myzus solani* (Kaltenbach), causes symptoms on the leaves of *P. obconica* in addition to those caused by the virus. The leaves on which either noninfective or infective foxglove aphids had fed showed circular, chlorotic areas around the mouth-part punctures (plate 2, *D*). The newly developing leaves on which no aphids had fed failed to show this symptom, hence the effect is local and not systemic. Other species of aphid vectors do not cause this symptom.

Experimental Host Range

According to Tompkins and Middleton (1941) the host range of the *P. obconica* mosaic disease is limited to two additional species within the genus, namely *P. malocoides* and *P. sinensis*. No infection was obtained by mechanical inoculation with the virus in 46 species of plants representing 42 genera in 23 families.

Since blisterlike elevations and the shoestring effect on the leaves of *P. obconica* resemble the symptoms of strains of cucumber-mosaic viruses, numerous series of inoculations were made to the following plants: Golden Self-Blanching celery (*Apium graveolens* var. *dulce*), White Spine cucumber (*Cucumis sativus*), Marglobe tomato (*Lycopersicon esculentum*), sugar beet (*Beta vulgaris*), *Nicotiana glutinosa*, Turkish tobacco (*N. tabacum*), and Zucchini squash (*Cucurbita pepo*). No symptoms appeared on any of these plants, nor was the virus recovered.

Aphid Transmission of Virus

Tompkins and Middleton (1941) tested the green peach aphid, *Myzus persicae* (Sulzer), and the lily aphid, *Myzus circumflexus* (Buckton), which are known to occur in the local greenhouses. Noninfective aphids were permitted to feed for 24 to 48 hours on infected plants and were then transferred to healthy plants. All attempts to transmit the virus by means of aphids were unsuccessful.

Watson (1938), Watson and Roberts (1939), Kassanis (1941), Watson (1946), and Sylvester (1947) published data which indicate that a starvation period prior to a short infection feeding results in an increase in the transmission of nonpersistent viruses, when compared with the results obtained with unfasted, infective aphids.

By Single Unstarved and Starved Cotton or Melon Aphids. A comparison was made of the transmission of the virus by unfasted, infective, wingless, single cotton or melon aphids with the transmission by previously noninfective aphids starved for two to four hours, then fed one-half, one, two, five or ten minutes on an infected plant. The procedure was repeated in order to obtain five replications of each short infection-feeding period. Twenty-five unfasted, single infective aphids failed to transmit the virus. One infection was obtained with a starved aphid with an infection-feeding interval of two minutes, while 24 single, starved aphids failed to produce infections with infection-feeding period of one-half, one, two, five, or ten minutes.

By Lots of 20 Unfasted, Infective Aphids. Nine species of aphids were tested for virus transmission. Previously noninfective, unfasted, wingless aphids were fed on infected plants for one day, and then were transferred in lots of 20 aphids to healthy plants for two days. The infections were obtained for ten of 120 plants inoculated, or 8 per cent, as shown in table 1.

By Lots of 20 Fasted Aphids in Short Infection-Feeding Periods. Noninfective wingless aphids were starved in a phial for two to three hours. After fasting, each aphid was placed on a mosaic primrose leaf under a binocular microscope and observed to feed from one-half to ten minutes. The aphids were then transferred, 20 aphids to each healthy primula plant, and left

for two days. Eighteen infections were obtained among the 120 plants inoculated, or 15 per cent, as shown in table 1. The cotton aphid was the most efficient vector in short infection-feeding intervals, transmitting the virus to 12 of 25 plants inoculated. The foxglove aphid infected six of 20 plants.

No infections were obtained with the unfasted, infective yellow willow aphid, *Cavariella aegopodii* (Scopoli), green peach aphid, *Myzus persicae* (Sulzer), honeysuckle aphid, *Rhopalosiphum conii* (Davidson), and turnip or false cabbage aphid, *R. pseudobrassicae* (Davis) previously fed on mosaic-

TABLE 1

COMPARISON OF TRANSMISSION OF *PRIMULA-OBCONICA*-MOSAIC VIRUS BY UNFASTED, INFECTIVE, WINGLESS APHIDS WITH FASTED APHIDS IN SHORT INFECTION-FEEDING PERIODS, 20 APHIDS IN EACH LOT

Common and scientific names of aphids	Unfasted infective aphids		Fasted aphids in short infection feeding periods	
	Plants inoculated	Plants infected	Plants inoculated	Plants infected
Celery aphid, *Aphis apii**	10	2	10	0
Rusty-banded aphid, *Aphis ferruginea-striata*	10	0	10	1
Cotton or melon aphid, *Aphis gossypii*	25	1	25	12
Bean or dock aphid, *Aphis rumicis*	10	0	10	2
Cabbage aphid, *Brevicoryne brassicae*	10	1	10	0
Lily aphid, *Myzus circumflexus*	25	0	25	1
Ornate aphid, *Myzus ornatus*	10	1	10	0
Foxglove aphid, *Myzus solani*	10	4	10	2
Pea aphid, *Macrosiphum pisi*	10	1	10	0
Total	120	10	120	18

* According to E. O. Essig (personal interview), *Aphis apii* Theobald may be identical with *A. helianthi* Monell.

infected primrose plants. Since the green peach aphid occurs on *P. obconica* in greenhouses, repeated tests were made, 25 lots of 20 unfasted infective aphids and 25 lots of 20 fasted aphids in short infection-feeding periods being used, but no infection was obtained.

Control

Tompkins and Middleton (1941) reported that to reduce, if not eliminate, the mosaic disease of *P. obconica* careful roguing of diseased plants was practiced, and the greenhouses were fumigated weekly with nicotine dust. The incidence of the disease was quickly reduced, until at present it is believed that the disease has been entirely eradicated in these greenhouses.

Plants inoculated with the virus were kept in a greenhouse at Berkeley which was fumigated weekly with nicotine dust. Healthy plants were kept in another greenhouse and sprayed weekly with Black Leaf 40 and Volck. During the past five years no accidental infection occurred among the healthy plants.

WESTERN CUCUMBER MOSAIC

Tompkins and Middleton (1941) briefly described the symptoms of western cucumber mosaic on the leaves and flowers of *P. obconica.*

At the onset of the disease, plants infected with western cucumber mosaic occasionally showed cleared veinlets around interveinal green or chlorotic circular areas about one month after inoculation. The intermediate and older leaves develop a coarse mottle accompanied with large, irregular, dark-green blisterlike elevations (plate 4, *A*) or flat dark-green islands in yellow areas (plate 4, *B, C*). The oldest leaves show a conspicuous white chlorosis (plate 4, *D, E*). Severe breaking in color of the petals occurs (plate 1, *B*). In the advanced stage of the disease, malformation of the youngest leaves may occur (plate 3, *F*). The symptoms of western cucumber mosaic on the leaves can be distinguished from those of celery calico and common cucumber mosaic by the large, dark-green blisterlike elevations.

CELERY CALICO

Tompkins and Middleton (1941) reported that no infection of primrose resulted from mechanical inoculations with the celery-calico virus.

The calico-virus extract from celery, when inoculated into the leaves of *P. obconica,* frequently failed to produce infection in the present experiments.

The first symptom of celery calico on the youngest leaves of *P. obconica,* two to three weeks after mechanical inoculation, is cleared veins and veinlets (plate 2, *B*) sometimes accompanied with a cupping of the youngest leaves. The younger leaves develop a yellow-green mottle. The symptoms on the intermediate and old leaves are more conspicuous and variable, consisting of numerous small or large, flat, circular or irregular, dark-green islands embedded in yellow areas (plate 5, *A, B*), or irregular, interveinal, slightly raised, dark-green areas (plate 5, *C, D*). Sometimes dark-green veinbanding occurs on some of the leaves (plate 5, *E*). In the advanced stage of the disease the old leaves become chlorotic (plate 5, *F*). Breaking in color of the flower petals occurs (plate 1, *B*). The variable symptoms of celery calico cannot be distinguished from those induced by the *Primula*-mosaic virus.

COMMON CUCUMBER MOSAIC

Smith (1935) in England described the symptoms produced by cucumber virus 1 on the leaves of *P. obconica.* The rubbed leaves became discolored, while the younger leaves developed a faint dark- and light-green mottle, the dark color being associated with the veins, giving a veinbanding effect. Infected plants made very little growth. Later Smith (1937*a*) stated that *Cucumis* virus 1 sometimes causes breaking in color of flower petals. *Cucumis* virus 1c, a strain, induces "a pronounced yellow and green mottling."

Primula japonica is a host of cucumber virus 1 (Ainsworth, 1937). *P. bulleyana* has also been reported susceptible to infection by this virus (Beaumont, 1938). Dennis and Foster (1942) recorded a virus which may be *Cucumis* virus 1, or *Lycopersicon* virus 3 K. M. Smith, on *Primula* glasshouse species in Scotland.

Dodge and Rickett (1943) found an infectious virus, affecting *P. obconica,*

similar to the strain that causes cucumber mosaic. There is a dark-green mottling of the leaves, which are later killed.

The first symptom of common-cucumber-mosaic virus which occasionally develops on the youngest leaves of *P. obconica* is a clearing of the veins and veinlets. A variable mosaic pattern appears on the intermediate and older leaves, consisting of irregular chlorotic areas within the dark-green portion of the leaf (plate 6, *A*), marginal chlorosis (plate 6, *B*), flat dark-green islands embedded in yellow areas (plate 6, *C*) and small, blisterlike elevations. Sometimes numerous, small, irregular dark-green areas develop in the yellow areas (plate 6, *D*). On rare occasions, the youngest leaf may be malformed (plate 6, *E*), or mottled and cupped downward. Color-breaking of the petals occurs. Again the variable symptoms of common-cucumber-mosaic virus cannot be distinguished from those induced by the *Primula*-mosaic virus.

ORDINARY TOBACCO MOSAIC

Holmes (1946) infected *P. obconica* with the tobacco-mosaic virus.

The leaves of *P. obconica* were inoculated with the tobacco-mosaic virus. No symptoms developed. The virus was recovered 30 days later from the inoculated leaves, but not from the younger and intermediate leaves and noninoculated roots. The infection was local and not systemic.

TOBACCO NECROSIS

Smith (1937 b, c) reported tobacco-necrosis virus in the roots of normal-looking *P. obconica.* Bawden and Kassanis (1947) isolated a tobacco-necrosis virus from the leaves and flowers of naturally infected *P. obconica* obtained from a nursery in Folkestone, England.

Natural infection of *P. obconica* with the tobacco-necrosis virus in a conservatory at Pittsburgh, Pennsylvania, has been demonstrated (Price, McWhorter, and Steranka, 1950).

TOMATO SPOTTED WILT

In 1935, Ogilvie listed *P. malacoides* and *P. sinensis* as hosts of the virus.

Natural infection of *P. obconica* by the kromnek (spotted wilt) virus was observed in Rhodesia (Hopkins, 1943).

The symptoms of spotted wilt on *P. malacoides* reportedly consist of yellowing of the leaves, which eventually wither, and marked stunting. Infected plants rarely flower and the disease is usually fatal. On *P. sinensis,* irregular necrotic lesions develop on the leaves, usually near the edges. Fusion occurs, imparting a scorched appearance; eventually the affected leaves die. Venation of the younger leaves is accentuated and slightly yellow. Infected plants are stunted and seldom flower. Large necrotic lesions develop on leaves artificially inoculated (Smith, 1937*b*). *P. obconica* is also a host of the spotted-wilt virus (Smith, 1937*b*, 1947).

Chamberlain and Taylor (1938) experimentally infected *P. obconica* and *P. sinensis* with spotted wilt and then recovered the virus from diseased plants.

Numerous attempts were made by the authors to transmit the spotted-wilt virus to *P. obconica* by mechanical inoculation, using many species of infected

host plants, but usually without results. The virus extract from one of six pink and white callas gave positive results. The virus was recovered from infected *P. obconica* plants and transferred to Marglobe tomatoes (*Lycopersicon esculentum*).

The symptoms of spotted wilt on the leaves of *P. obconica* are similar to those described by Smith (1937*b*, 1947) on *P. sinensis*. The first symptom on *P. obconica* is a yellowing of the margin of inoculated leaves (plate 7, *A*), followed by fusion of chlorotic areas, resembling scorching (plate 7, *B*). Necrotic lesions develop on the inoculated leaves (plate 7, *C, D*). Infected plants are stunted, and the yellow leaves wilt and become dry, killing the plants. The type of infection is systemic.

VIRUSES TRANSMITTED BY LEAFHOPPERS

Leafhoppers transmit two viruses to species of *Primula*. Kunkel (1926) experimentally infected *P. elatior* with the New York aster-yellows virus by means of the aster leafhopper, *Macrosteles divisus* (Uhler). Severin and Freitag (1945) recovered the California aster-yellows virus from naturally infected polyanthus primrose, *P. polyantha*, with the aster leafhopper.

Freitag and Severin (1936) experimentally infected three species of primula, including *P. obconica*, with the curly-top virus by means of the beet leafhopper, *Circulifer tenellus* (Baker).

California Aster Yellows

Symptoms induced on *P. polyantha* (Severin and Freitag, 1945) consist of stunting of infected plants, with numerous axillary shoots; leaves are yellow, the youngest leaves linear; flowers are green with shortened peduncles.

The first symptoms induced by the California aster-yellows virus on *P. obconica* plants infected by means of the aster leafhopper, *Macrosteles divisus*, is a clearing of the veins and veinlets with yellow veinbanding (plate 2, *C*). The newly developing leaves are dwarfed, with twisted petioles, and a general yellowing of the older leaves occurs (plate 8, *A*). Virescence or greening, dwarfing, and malformation of the flowers (plate 8, *C, E, F*), are striking symptoms of the disease.

SUMMARY

The symptoms of mosaic on *Primula obconica* are described on experimentally infected plants. The incubation period of the disease ranged from 18 to 26 days.

The lily aphid, *Myzus circumflexus* (Buckton), which breeds on *P. obconica* in greenhouses in the San Francisco Bay area, is a vector of the virus. The ornate aphid, *Myzus ornatus* Laing, which multiplies on this host plant in cages, is also a vector of the virus. No infections were obtained with the green peach aphid, *Myzus persicae* (Sulzer).

The following seven species of aphids which do not multiply on *P. obconica* are vectors of the virus:

Celery aphid, *Aphis apii* Theobald
Rusty-banded aphid, *Aphis ferruginea-striata* Essig
Cotton or melon aphid, *Aphis gossypii* Glover

Bean or dock aphid, *Aphis rumicis* L.
Cabbage aphid, *Brevicoryne brassicae* (L.)
Foxglove aphid, *Myzus solani* (Kaltenbach)
Pea aphid, *Macrosiphum pisi* (Kaltenbach)

Nine species of infective aphids transmitted the virus to ten of 120 plants inoculated, or 8 per cent, and the same species of aphids in short infection-feeding periods to 18 of 120 plants, or 15 per cent.

The symptoms of western-cucumber-mosaic virus on the leaves of *Primula obconica* can be distinguished from those of the celery-calico virus and common-cucumber-mosaic virus by large, irregular, dark-green blisterlike elevations, and by severe breaking in color of flower petals, whereas a mild breaking is induced by the celery-calico and common-cucumber-mosaic viruses. Other symptoms of the three cucumber-mosaic viruses are dark-green or yellow areas, and occasionally leaf malformations. The variable symptoms of celery calico and common cucumber mosaic cannot be distinguished from those induced by the mosaic virus on *P. obconica.*

P. obconica is a symptomless carrier of the ordinary-tobacco-mosaic virus. The infection was local, not systemic, in inoculated plants.

In the few successful transmissions of tomato-spotted-wilt virus by mechanical inoculation in the greenhouse, symptoms on *P. obconica* consisted of yellowing of the margin of inoculated leaves, followed by fusion of chlorotic areas, resembling scorching, and necrotic lesions. Infected plants were stunted and the yellow leaves wilted, became dry, and killed the plants. The infection was systemic.

California aster-yellows virus transmitted by the aster leafhopper, *Macrosteles divisus* (Uhler), induces in *P. obconica* a clearing of the veins and veinlets with yellow veinbanding on the youngest leaves, dwarfing of the newly developing leaves, and general yellowing of the older leaves. Virescence, or greening of the flowers, is a striking symptom of the disease.

LITERATURE CITED

AINSWORTH, G. C.
1937. Virus diseases. Ann. Rpt. Exp. and Res. Sta. Cheshunt, Hertfordshire. **22**(1936): 59–62.

BAWDEN, F. C., and B. KASSANIS.
1947. *Primula obconica*, a carrier of tobacco necrosis viruses. Ann. Appl. Biol. **34**:127–35.

BEAUMONT, A.
1938. Fifteenth annual report of the Department of Plant Pathology for the year ending September 30, 1938. 39 p. Seale-Hayne Agr. College, Newton Abbott, Devon. Pamphlet No. 49.

CHAMBERLAIN, E. E., and G. G. TAYLOR.
1938. Spotted wilt. Host range and transmission by thrips. New Zealand Jour. Sci. and Techn. **20**:133A–142A.

DENNIS, R. W. G., and C. E. FOSTER.
1942. List of diseases of economic plants recorded in Scotland. British Mycol. Soc. Trans. **25**:266–306.

DODGE, B. O., and H. W. RICKETT.
1943. Diseases and pests of ornamental plants. 498 p. The Cattell Press, Lancaster, Pa.

FREITAG, J. H., and H. H. P. SEVERIN.
1936. Ornamental flowering plants experimentally infected with curly top. Hilgardia **10**(9):263–302.

HOLMES, F. O.
1946. A comparison of the experimental host ranges of tobacco-etch and tobacco-mosaic viruses. Phytopathology **36**(8):643–59.

HOPKINS, J. C. F.
1943. Mycological notes. 16. The campaign against the kromnek virus. Rhodesia Agr. Jour. **40**:47–49.

KASSANIS, B.
1941. Transmission of tobacco etch viruses by aphides. Ann. Appl. Biol. **28**:238–43.

KRISTENSEN, H. RONDE.
1949. Mosaiksyge hos *Primula obconica*. Gart.-Tidende **65**(13):139–41.

KUNKEL, L. O.
1926. Studies on aster yellows. Amer. Jour. Bot. **13**:646–705. (*Also in:* Boyce Thompson Inst. Contrib. 1, 181–240.

MOORE, W. C.
1947. Report on fungus, bacterial, and other diseases of crops in England and Wales for the years 1943–1946. (Gt. Brit.) Ministry of Agr. and Fisheries. Bul. **139**:1–90.

OGILVIE, L.
1935. Spotted wilt of tomatoes and its control. Rpt. Agr. Hort. Res. Sta. Bristol, **1934**: 170–74.

PRICE, W. C., F. P. MCWHORTER, and B. H. STERANKA.
1950. Natural occurrence of tobacco necrosis virus in primrose. Phytopathology **40**(4): 391–92.

SEVERIN, H. H. P., and J. H. FREITAG.
1945. Additional ornamental flowering plants naturally infected with California aster yellows. Hilgardia **16**(12):599–618.

SMITH, K. M.
1935. A virus disease of *Primula obconica* and related plants. Ann. Appl. Biol. **22**(2): 236–38.
1937*a*. Studies on a virus found in the roots of normal-looking plants. Parasitology **29**: 70–85.

1937*b*. A textbook of plant virus diseases. 615 p. Blakiston's Son & Co., Philadelphia.

1937*c*. Further studies on a virus found in the roots of certain normal-looking plants. Parasitology **29**(1):86–95.

1947. Virus diseases of farm and garden crops. 111 p. Littlebury & Co., The Worcester Press, Worcester, England.

SYLVESTER, E. S.

1947. Influence of fasting in the transmission of beet-mosaic virus by green peach aphid. Phytopathology **37**(7):528–30.

TOMPKINS, C. M., and J. T. MIDDLETON.

1941. A mosaic disease of *Primula obconica* and its control. Jour. Agr. Res. **63**(11): 671–79.

WATSON, M. A.

1938. Further studies on the relationship between Hyoscyamus virus 3 and the aphis *Myzus persicae* (Sulz.) with special reference to the effects of fasting. Proc. Roy. Soc. London Ser. B, **125**:144–70.

1946. The transmission of beet mosaic and beet yellows viruses by aphides; a comparative study of a non-persistent and persistent virus having host plants and vectors in common. Proc. Roy. Soc. London Ser. B, **133**:200–19.

WATSON, M. A., and F. M. ROBERTS.

1939. A comparative study of the transmission of Hyoscyamus virus 3, potato virus Y and cucumber virus 1 by the vectors *Myzus persicae* (Sulz.), *M. circumflexus* (Buckton), and *Macrosiphum gei* (Koch). Proc. Roy. Soc. London Ser. B, **127**: 543–76.

141 4½*m*-10,'50(296)JB

PLATES

Plate 1. Breaking in color of flower petals of *Primula obconica* induced by three viruses: *A*, four flowers showing streaking and blotching induced by the mosaic virus, grouped around normal flower (center) from check or control plant; *B*, four flowers showing successive stages of white streaks to blanching induced by the western-cucumber-mosaic virus, grouped around dwarfed flower (center); *C*, center, malformed flower, others showing white streaks and blotching induced by the celery-calico virus.


A
B
C

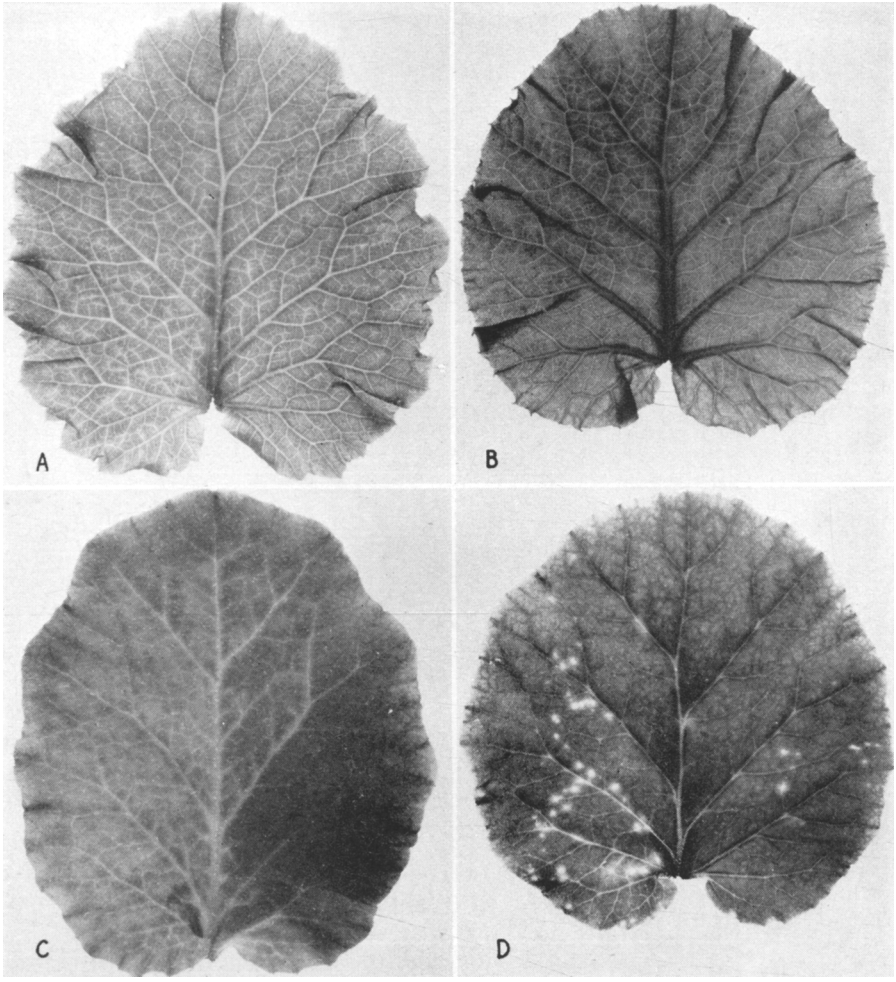

Plate 2. Virus symptoms on leaves of *Primula obconica: A*, cleared veins and veinlets on youngest leaf induced by a *Primula* mosaic; *B*, transparent venation on youngest leaf caused by the celery-calico virus; *C*, cleared veins and veinlets induced by California-aster-yellows virus; *D*, local symptoms on leaf on which noninfective foxglove aphids, *Myzus solani* (Kaltenbach), had fed, showing circular, chlorotic areas around mouth-part punctures.

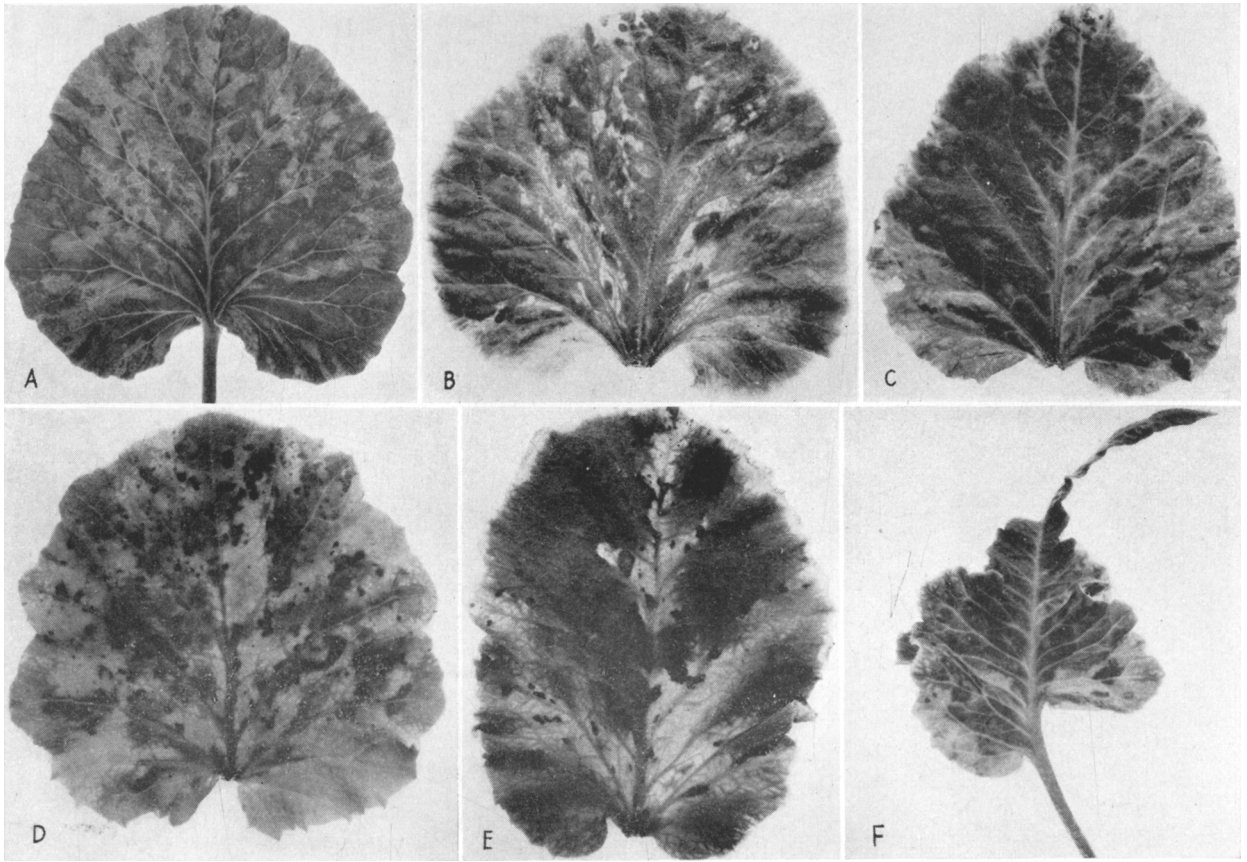

Plate 3. Symptoms of a *Primula*-mosaic virus on leaves of *Primula obconica: A*, yellow-green mottle; *B, C*, dark-green, blister-like elevations; *D*, flat, dark-green islands between and adjacent to the veins; *E*, large chlorotic areas with dark-green islands; *F*, shoestring effect at tip of leaf.

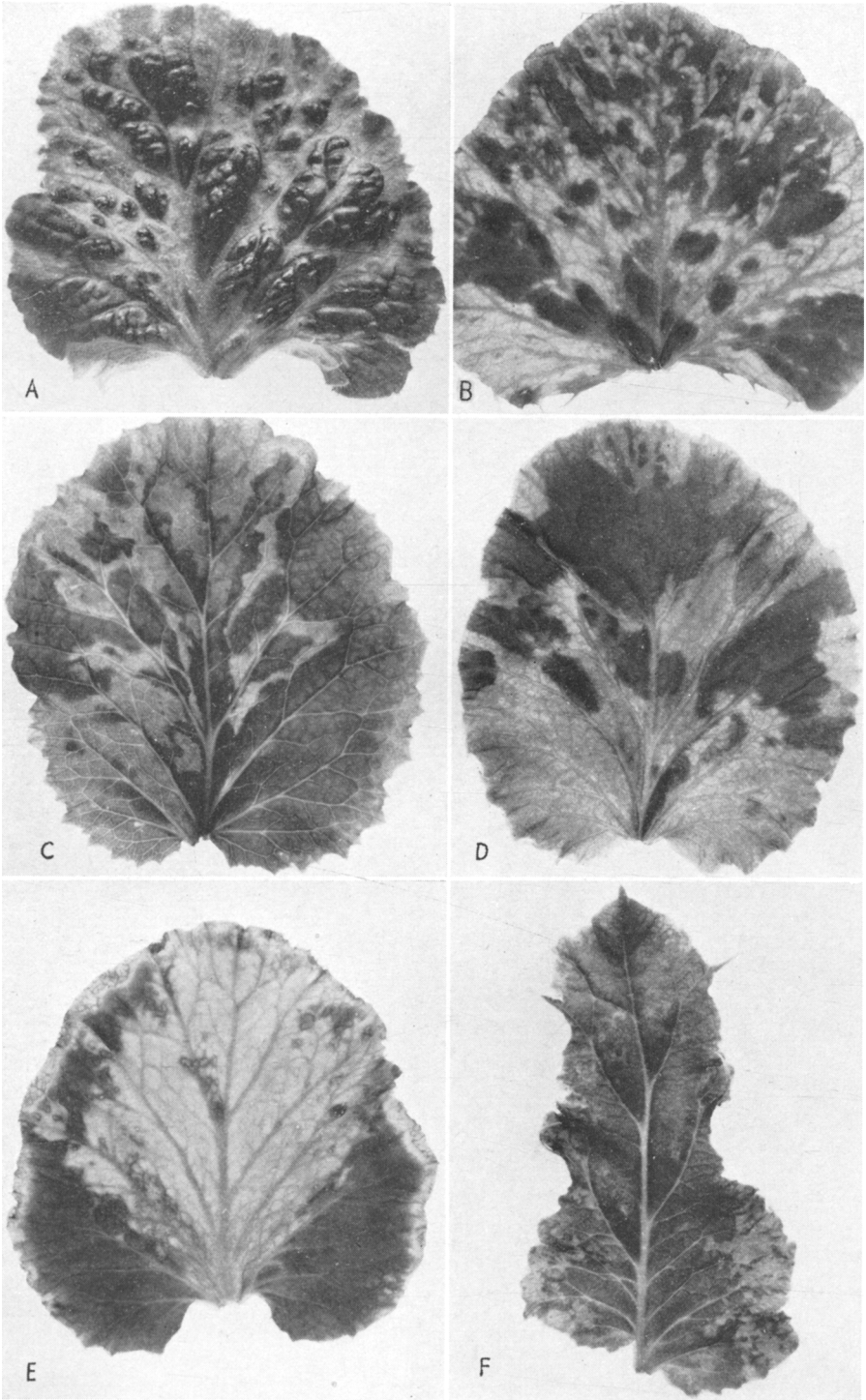

Plate 4. Symptoms of western-cucumber-mosaic virus on leaves of *Primula obconica: A*, large, irregular, dark-green blisterlike elevations; *B, C*, flat dark-green islands in yellow areas; *D, E*, conspicuous white chlorosis of oldest leaves; *F*, malformed leaf.

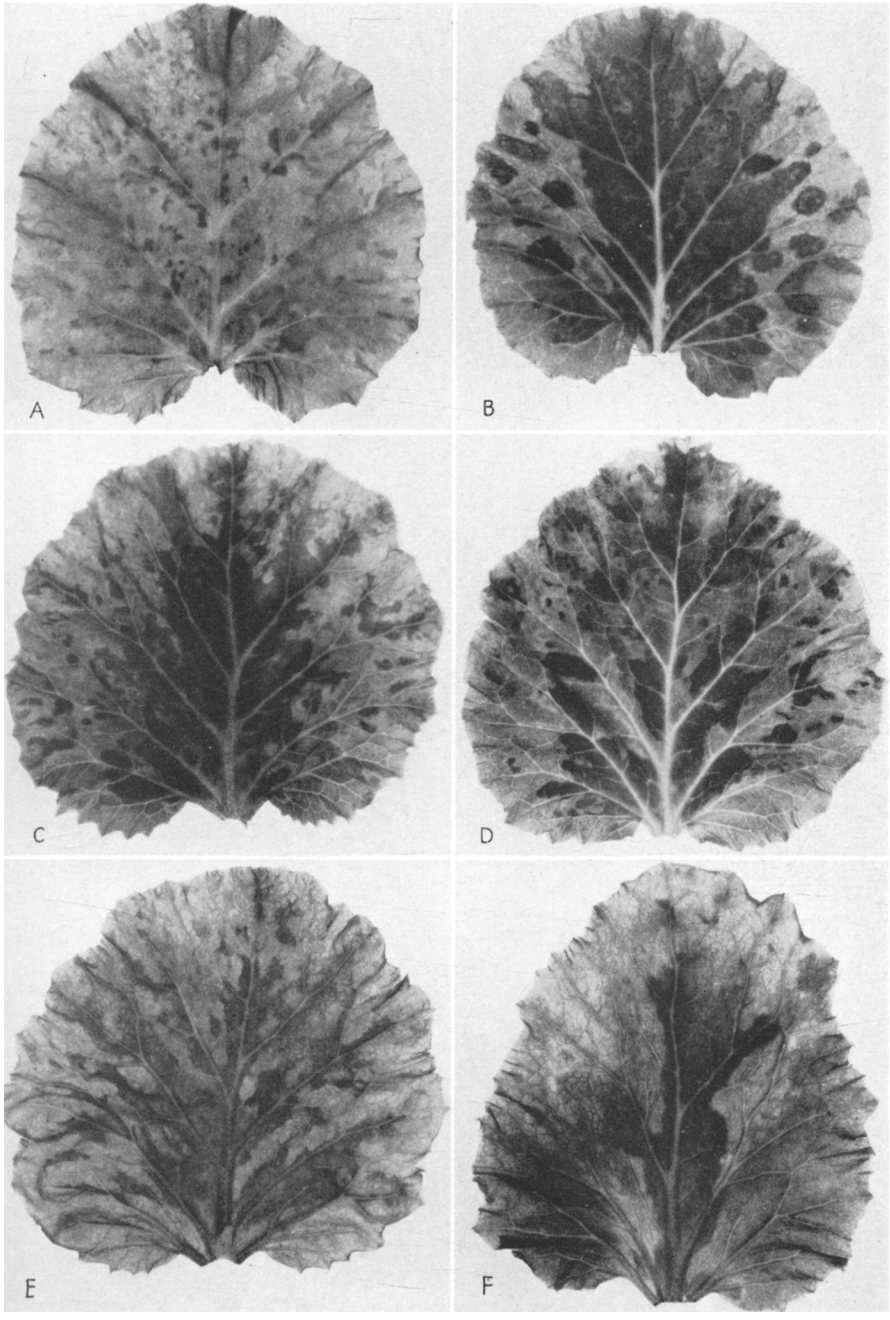

Plate 5. Symptoms of celery-calico virus on leaves of *Primula obconica: A*, numerous small or large green areas; *B*, flat, circular or irregular dark-green islands embedded in yellow areas; *C*, *D*, irregular, interveinal, slightly raised dark-green areas; *E*, dark-green veinbanding; *F*, chlorosis of old leaves.

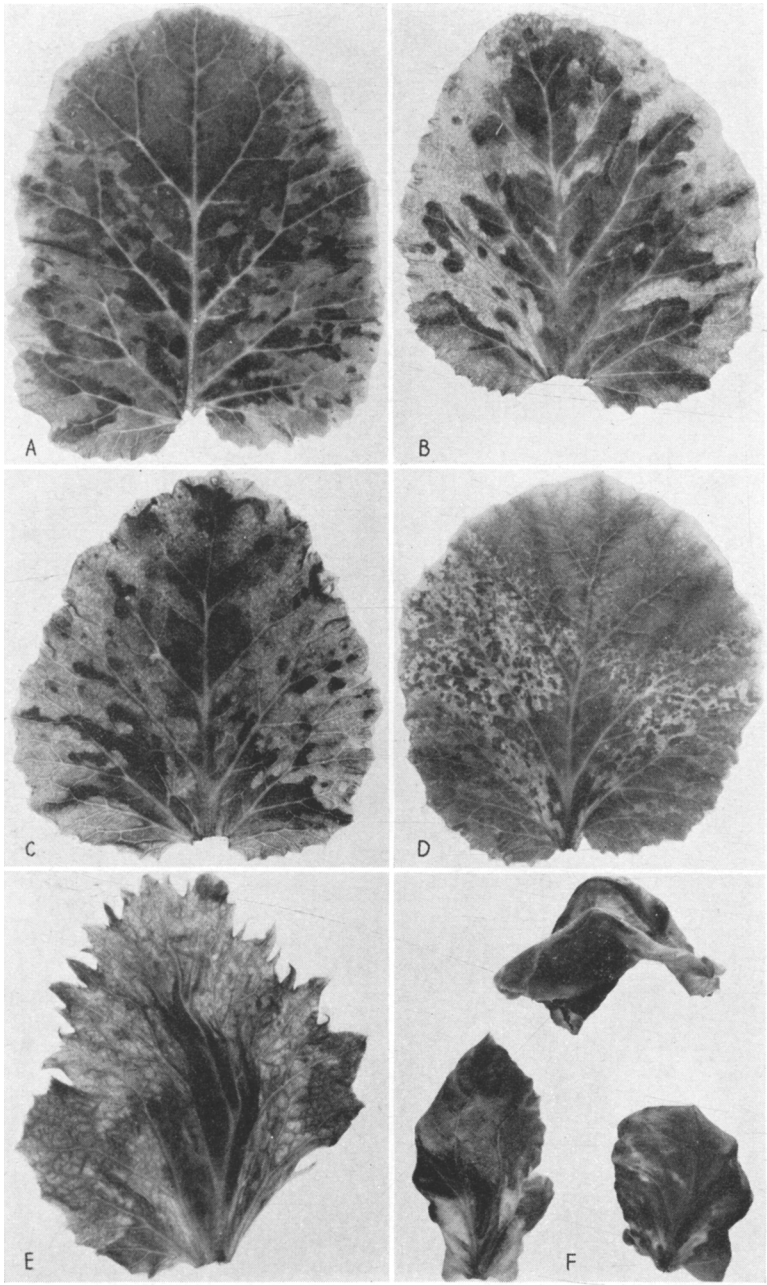

Plate 6. Symptoms of common-cucumber-mosaic virus on leaves of *Primula obconica: A*, irregular chlorotic areas within dark-green portion of leaf; *B*, marginal chlorosis; *C*, flat dark-green islands embedded in chlorotic areas; *D*, numerous small dark-green areas embedded in yellow tissue; *E*, malformed youngest leaf; *F*, mottling, downward cupping, and malformations of youngest leaves.

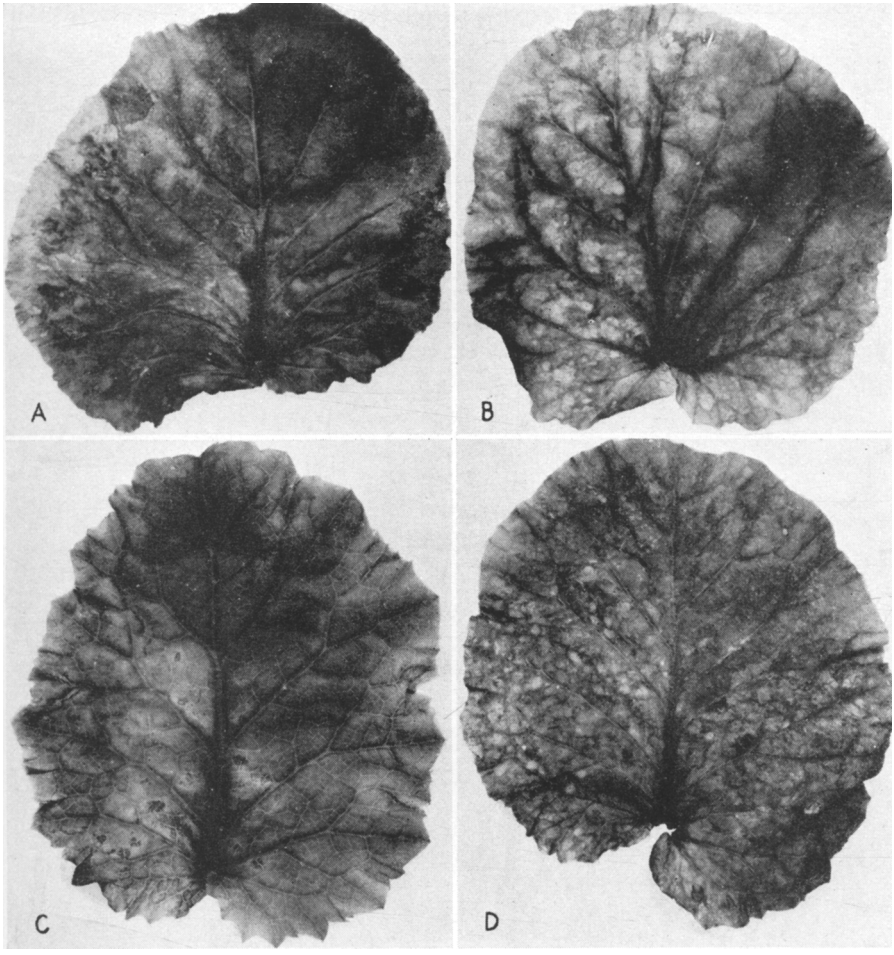

Plate 7. Symptoms of tomato spotted wilt on leaves of *Primula obconica: A*, yellowing of the margin of inoculated leaf; *B*, fusion of chlorotic areas resulting in scorched appearance; *C, D*, necrotic lesions.

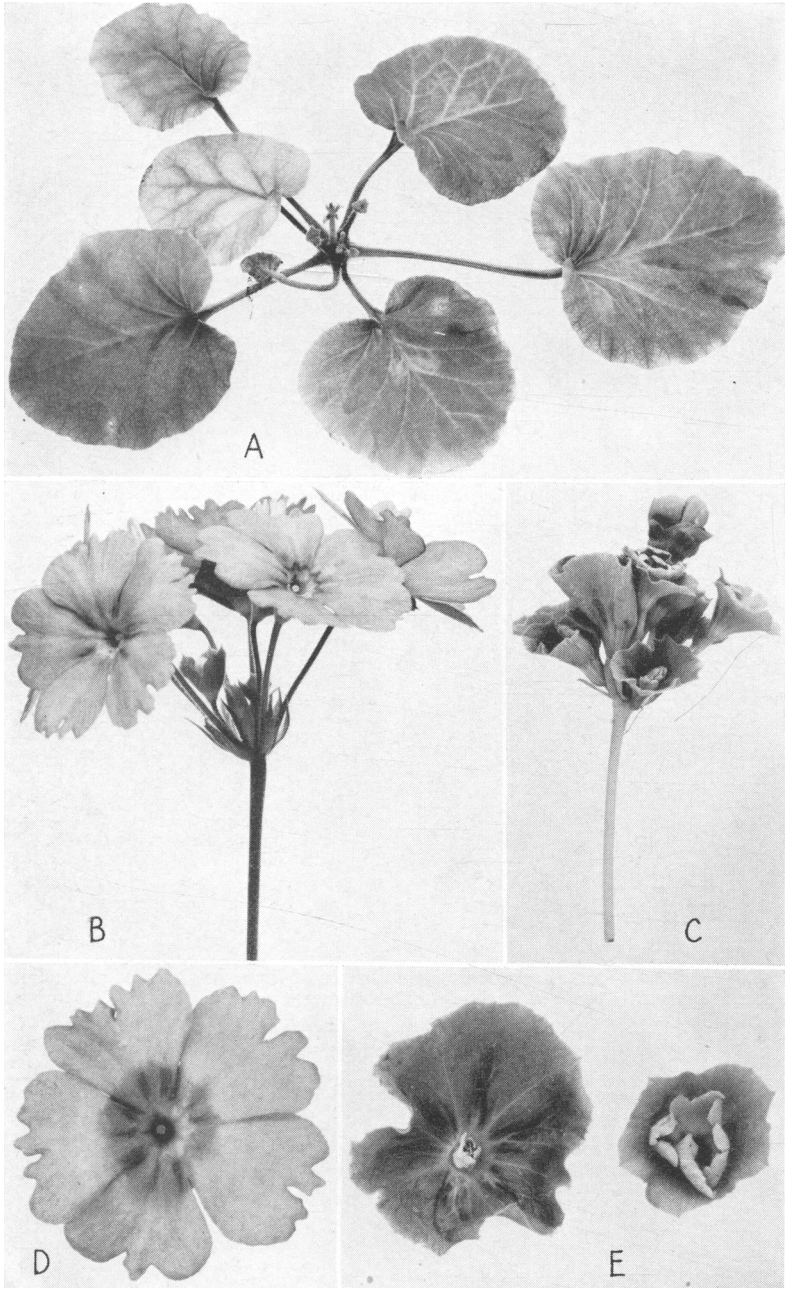

Plate 8. Symptoms of California-aster-yellows virus on *Primula obconica*: *A*, dwarfing of youngest leaves, twisting of petioles, and a general yellowing of older leaves; *B*, cluster of flowers from healthy check or control plant; *C*, virescence, or greening of cluster of flowers from an infected plant; *D*, normal flower from healthy plant; *E*, abnormal flower with reduced petals; *F*, green flower with inward-curled petals.

The journal *Hilgardia* is published at irregular intervals, in volumes of about 600 pages. The number of issues per volume varies.

Subscriptions are not sold. The periodical is sent as published only to libraries, or to institutions in foreign countries having publications to offer in exchange.

You may obtain a single copy of any issue free, as long as the supply lasts; please request by volume and issue number from:

Publications Office
College of Agriculture
Berkeley 4, California

The limit to nonresidents of California is 10 separate issues on a single order. A list of the issues still available will be sent on request.