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VIRUS DISEASES OF GERANIUM

Several diseases of geraniums (*Pelargonium* species) are caused by viruses. The economic losses caused by these diseases are difficult to assess since infected plants are often symptomless and because both the cultivar and the environment in which the plants are growing can greatly influence the severity of the symptoms. The problem is compounded by the diverse sources of stock plants and the fact that most geranium cultivars, especially those that are field-grown, are virus-infected.

Figure 1. Chlorosis of geranium (J.L. Forsberg)

Although viruses by themselves rarely, if ever, kill an infected plant, the plant's vigor and quality can be greatly affected. An unsightly spotting and distortion of leaves, a reduction in the number of blooms, and the abortion of flowers may result from virus infection. Sometimes viruses that individually fail to induce symptoms, occur in combination and cause severe disease. Geraniums with a virus infection are also more susceptible to bacterial blight and stem rot and possibly other diseases than are healthy plants.

Virus diseases became a serious problem in the Midwest when geranium growers stopped producing their own plants for stock and began to obtain their cuttings from California. Weeds and crop plants could act as virus reservoirs since California plants are grown outside. Insects or other vectors could transmit the viruses to geranium plants in the field. The symptoms induced in geraniums by viruses are generally masked throughout the summer and fall; also, symptomless cuttings taken from field-grown stock plants may be virus-infected. Infected cuttings that seem to be healthy when they are shipped from California in the fall commonly begin to show virus symptoms in Midwestern greenhouses during January and February. The symptoms of virus diseases vary considerably, depending on the cultivar.

Pelargonium Ringspot

Pelargonium ringspot may be caused by strains of tomato or tobacco ringspot viruses. Infections of tomato ringspot virus (TomRSV) produce varied patterns of yellow to dead (necrotic) spots, rings, broken-ring patterns and vein yellowing on normally shaped leaves in the early spring (Figure 1). Sometimes symptoms develop on mature leaves of symptomless plants below a pinch. The symptoms increase in severity on older leaves until mid-July, when they begin to fade. New leaves produced from mid-summer through early winter are generally symptomless. Occasionally, flowers on infected plants exhibit petal distortions and enations. Plant vigor may be severely reduced, thus decreasing the plant's commercial value.

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Geranium cultivars differ in the symptom expression caused by tobacco ringspot virus (TRSV) infection. Some cultivars display symptoms similar to those caused by TomRSV. Tobacco ringspot virus also causes plants to produce small and often malformed leaves, with small blisterlike areas and irregular yellow rings. Infection by TRSV and TomRSV reduces the number of florets, and mature inflorescences often produce aborted buds. Plants infected with both TomRSV and TRSV display much more severe symptoms than those infected by either virus alone. Double virus infections can seriously impair plant growth and appearance.

Both TomRSV and TRSV can be transmitted from one geranium to another by infected stem cuttings and by grafting. Tobacco ringspot virus can be transmitted between geraniums by infected sap, but TomRSV can only be sap-transmitted from geraniums to other types of plants, not to other geraniums. Tomato ringspot virus can also be transmitted from geraniums to other kinds of plants by dagger nematodes (*Xiphinema* spp). These nematodes are also a vector of TRSV, but have not been reported as a transmitting agent (vector) of this virus to or from geraniums.

Additionally, TomRSV and TRSV may be transmitted in geraniums through the seed. In seed transmission tests, 1- 30% of the seedlings from infected mother plants were diseased. The TomRSV can become seedborne via either infected female gametophytic tissue (ovule) or pollen, but transmission of TRSV occurs only through the ovule. Pollen transmission of TomRSV within the geranium crop represents a serious potential threat.

Pelargonium Leaf Curl or Crinkle

This disease is caused by the Pelargonium leaf-curl virus (PLCV), a strain of tomato bushy stunt virus. The incidence of the disease ranges up to 45 percent in various greenhouse stocks. The prevalence and severity of infections will differ according to the cultivar involved. The leaves of infected plants have round to star-shaped (asteroid) spots or irregular yellow ones, up to 1/5 inch in diameter. The leaves become crinkled, puckered, and may split as they expand (Figure 2). The spots are slightly thickened and hyaline, transmitting light when examined from the underside of the leaf. The centers of the older, yellowish spots may dry up and become brown with a chlorotic border. Severely infected leaves may turn yellow and drop off. In extreme cases, the top of an infected plant may turn brown and die. Other plants become disfigured and dwarfed.

Figure 2. Leaf curl or crinkle (Illinois Natural History Survey photo).

Cuttings taken in the autumn from apparently healthy plants exhibit typical symptoms when new leaves develop during the winter and early spring. The severity of the symptoms increases until March, when recovery begins, but the plants are still unsightly during the peak sales period in April and May. The plants are symptomless during the summer months, and PLCV is difficult to isolate from them at this time. The causal virus is graft-transmitted, and sap-transmissible with some difficulty.

Leaf Breaking and Mosaic

Leaf breaking and mosaic is thought to be caused by strains of cucumber mosaic virus (CMV). The symptoms of this disease are typified by definite light green or chlorotic areas between the veins with dark

green areas along the veins (Figure 3). Sometimes only a portion of the leaf is affected. The purplish zones or horseshoe patterns of normal leaves may disappear (Figure 3) and be replaced by purple spotting along the veins. This condition is due to either a complete rearrangement of or a reduction in the formation of anthocyanin pigments. Leaves on severely infected plants are lighter green than normal, stunted, and shaped like the leaf of a ginkgo. Leaf breaking is seasonal and most severe in winter. Symptoms are masked in summer and during bloom, but infected plants may still be unsightly during the peak sales period. The incidence of leaf breaking has increased greatly in the past few years where culture-indexed plants are not grown, but is still less prevalent and injurious than the effects of leaf curl and ringspot. Several geranium cultivars are known to be 100-percent affected by leaf breaking. The virus is both sap- and graft-transmitted, and may also be aphidborne.

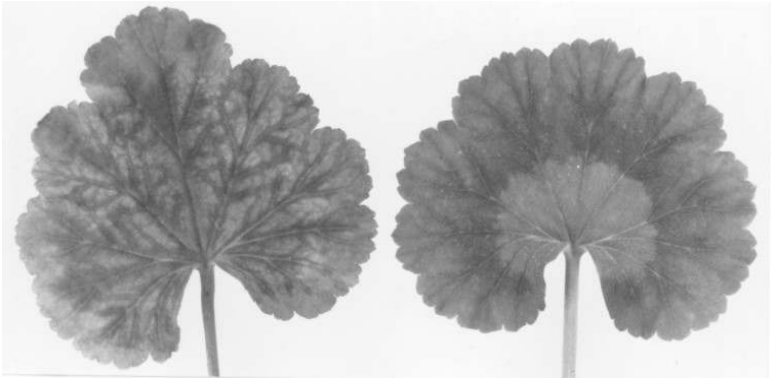

Figure 3. Leaf breaking. The geranium leaf on the left is affected by the disease. The leaf to the right is healthy (Il Natural History Survey photo).

Yellow-Net Vein

Yellow-net vein appears as a striking yellow and white vein clearing in the primary and secondary veins (Figure 4). No leaf distortions or flower and stem abnormalities are associated with this disease. Infected plants can exhibit a series of yellow-veined leaves alternating with a series of symptomless leaves. The symptoms of yellow net-vein are most severe from December through February. During the remainder of the year, the symptoms persist along the veins of both young and old leaves but are not so pronounced. Yellow-net vein is a suspected virus disease and is transmitted by infected stem cuttings and grafting.

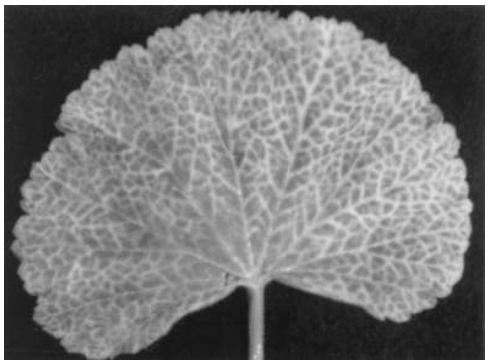

Figure 4. Yellow-net vein (Pennsylvania State University photo).

Pelargonium Ring Pattern

The Pelargonium ring pattern virus (PRPV) produces symptoms similar to Pelargonium ringspot. Unlike ringspot, ring pattern does not infect *Pelargonium peltatum* and produces true ring patterns in *P. zonale.* Symptoms develop 1 to 12 months after infection as yellow ringspots in mature leaves. Ring pattern is apparently more prevalent in older geranium cultivars, although the virus has been detected on some more recently introduced cultivars. The virus is transmitted by infected cuttings, grafting, and sap.

Pelargonium Flower Break

This rare disease is caused by the Pelargonium flower break virus (PFBV). Although serologically distinct from other viruses that infect geranium, PFBV is difficult to detect because it occurs in low concentrations in the plant and is symptomless in most cultivars. Susceptible geranium cultivars show a breaking of flower color which appears as light colored streaks in the petals. Plant growth is retarded and flowers are smaller with rugosed petals. The virus has only been isolated from *P. zonale* and attempts to infect *P. peltatum* have failed. The virus is transmitted by infected cuttings, grafting, and sap.

Spotted Wilt

This rare disease is caused by strains of the tomato spotted wilt virus (TSWV). Infected geraniums display an occasional leaf with bright yellow or whitish spots that are often arc- or ring-shaped (Figure 5). Spotted wilt is often confused with leaf curl because of the bright yellowish spots. The spots produced by TSWV, however, do not transmit light, as do those associated with leaf curl. Tomato spotted wilt virus is transmitted by grafting and by several species of thrips.

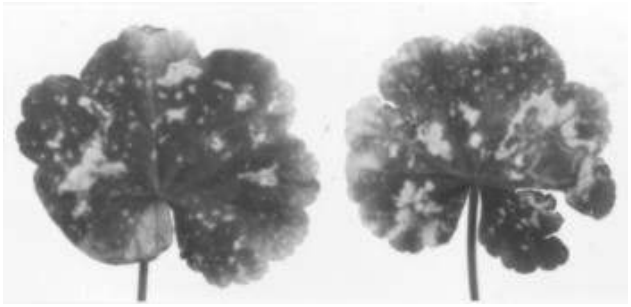

Figure 5. Spotted wilt on two geranium leaves. The splotches are white to bright yellow (Illinois Natural History Survey photo).

Leaf Cupping

This rare disease, caused by the beet curly top virus, is probably the most destructive and distinctive virus disease of geraniums. It is so destructive that infected plants are rarely found in commercial stocks. The normal, flat, pubescent leaves are changed into incurved, hairless "cups" (Figure 6). The lower and older leaves may become yellowish between the veins. In an advanced stage of the disease the entire plant may be chlorotic. Symptoms of leaf cupping appear in autumn and again in spring. Beet curly top virus is transmitted by grafting and by the feeding of the beet leafhopper (*Circulifer tenellus*) but not by sap, dodder, or aphids.

Figure 6. Leaf cupping (Pennsylvania State University photo).

Tobacco Viruses

Three viruses common to the tobacco plant have been reported as infecting geraniums to some extent. Tobacco necrosis virus has been isolated from the roots of symptomless geraniums. Light-colored lesions appear on the lower leaves when infected plants are grown under low-light and low-temperature conditions. The tobacco strain of tobacco mosaic virus causes a yellow chlorosis with a few, minute brown spots on the leaves. Tobacco viruses are transmitted in infected plant parts, by grafting, and by sap. Geraniums may become infected with tobacco rattle virus when plants are grown in soil infested with several species of stubby-root (*Trichodorus*) nematodes known to transmit the virus.

Other Viruses

Several other viruses including tomato black ring virus, Arabis mosaic, Pelargonium line pattern, Pelargonium zonate spot, an unidentified isometric virus, and a bacilliform particle associated with vein-clearing and vein-banding symptoms have been reported in geraniums. In most instances, it is unclear whether these viruses incite specific diseases and whether they occur too infrequently to be considered economically important. The viruses are transmitted by infected plant parts (cuttings), by grafting, and by sap.

Double Infections

Geranium plants infected with a single virus suffer a reduction in quality, but few plants are killed. However, double infections may severely stunt or kill plants. The following viruses have been found in mixed infections: tobacco ringspot and tomato ringspot; yellow-net vein and beet curly-top; tomato spotted wilt and tomato bush stunt.

Epidemiology

In general, virus symptoms first appear in the late winter or early spring. The new growth produced in summer is usually symptomless. Plants commonly remain free of symptoms from the late summer to mid-winter.

By far the most important method of spread of viruses is by stem cuttings used for vegetative propagation. Since geraniums are propagated from relatively few source ("mother") plants, the potential arises for virtually the entire plant population to be infected. Generally, geranium plants vegetatively propagated from virus-infected mother plants are infected.

Sap transmission of viruses from one geranium to another on cutting knives and by handling has proven to be difficult. Transmission is particularly difficult in the summer when the virus concentration in the host is low. Also, virus inhibitors may be more concentrated in the sap of virus-infected geraniums during the summer.

The relationships of insects as vectors in transmitting geranium viruses have not been determined. Many insects–such as aphids in the case of cucumber mosaic virus–known to transmit the viruses that infect geraniums have failed to transmit these viruses to geraniums. Some insect vectors will not even feed on geraniums. Geraniums in California fields harbor populations of whiteflies, leafhoppers, and aphids, so it does not seem unreasonable that insect transmission occurs, particularly in areas where stock plants for vegetative propagation are grown outdoors.

Control

Large-scale control of geranium virus diseases can be divided into three major areas: (1) indexing to identify infected plants; (2) producing virus-free plants; and (3) maintaining disease-free plants.

A. Start with virus-free plants. It is imperative that florists obtain "culture-indexed" cuttings from a commercial propagator who has established virus-free planting stock and practices strict sanitary measures. Culture-indexed cuttings are used to set up an increase or mother block of virus-free plants. This is best accomplished using a combination of destroying (roguing) infected plants and periodic systematic testing of stock plants where virus or other diseases are suspected.

    1. Virus-indexing is the most important step. Diagnosis of virus-infected but symptomless geranium plants may be accomplished by grafting to susceptible geranium cultivars or wild species of *Pelargonium* and by sap transmission to other herbaceous indicator plants such as species of *Chenopodium*, tobacco, lambsquarter, peas, French beans, petunia, and cowpea that exhibit reliable symptoms. It takes two years to produce suitable geranium tester plants from seed.

        Serological tests (e.g., ELISA) are now routine in virus laboratories where antisera and

equipment are available. Viruses such as cucumber mosaic, TomRSV, and TRSV are most easily detected in young leaves, flowers, and ligula. The ELISA test is currently the most rapid, economical, and convenient method for commercial indexing and is more reliable than bioassay on indicator plants.

B. Viruses can be eliminated from a desirable variety by using various techniques. Some geranium clones from the same source may be virus-free. These can be selected to perpetuate the line. Alternatively, shoot tips from rapidly growing stems may be virus-free, and geranium plants started between March and September from small tip cuttings will often be virus-free. This method is employed for the leaf curl or crinkle disease. Growing infected plants at high temperatures for prolonged periods has been used to produce virus-free carnations and chrysanthemums. Geraniums infected with leaf curl or ringspot and grown at 100°F (37°C) for 4 weeks produce small shoots with tips that are free of the virus(es). Meristem tip culture is another possible method of eliminating viruses from geraniums. It is also possible to obtain single, virus-free cells from a callus culture derived from an infected plant. Techniques for regenerating such geranium cells into an intact plant are largely in the future, however.

C. Geraniums free of viruses and other pathogens can be maintained by following strict sanitary precautions to prevent contamination of healthy plants:

1. All infected plants should be immediately removed and destroyed, preferably by burning.

2. Florists should use an automatic watering system. If this is impossible, hang the hose so the nozzle does not touch the greenhouse floor.

3. When propagating, select a raised bench away from other areas where geraniums are produced. The bench surface should be wiped or sprayed with a fresh household bleach (Clorox, Purex, Sunny Sol) solution, prepared by adding 1 part of liquid bleach to 4 parts of water.

4. Steam the propagating medium, soil mix, flats, clay pots, and tools for 30 minutes at 180°F (82°C) at the coolest spot.

5. Wash hands thoroughly with soap and hot running water before handling plants. Take cuttings from disease-free stock plants by (a) breaking out succulent tips or (b) sterilizing the cutting knife or razor blade by dipping it in 70-percent solution of rubbing alcohol and flaming. Knives or razor blades should be changed between geranium stock plants.

6. Place cuttings in clean, sterile flats lined with fresh newspapers.

7. After establishment, take the cuttings from the flats and plant them directly into steam-treated soil mix in pots. The handling of plants should be kept to a minimum in order to avoid the spread of certain viruses and other pathogens by mechanical means.

8. Maintain good cultural conditions and ventilation. Eliminate all plant debris and unsterilized soil that could act as a source of contamination.

9. Control whiteflies, aphids, thrips, and other insects according to the recommendations of University of Illinois Extension entomologists.

10. Avoid forcing plants too rapidly, especially during warm, humid weather when the temperatures are 70° to 85°F (21° to 29°C).

11. Maintain balanced fertility based on a soil test.