SECTION 2

Virus and Viruslike Diseases of Gooseberry and Currant

J. M. THRESH
Associate Editor

INTRODUCTION

Virus and Viruslike Diseases of *Ribes* Crops

J. M. Thresh

THE GENUS *Ribes* L. (Saxifragaceae: subfamily Ribesioideae Engler and Prantl) comprises more than 150 woody species. These are deciduous (rarely evergreen) shrubs that begin to grow and flower early in spring, and usually ripen their fruit in midsummer. The fruits are juicy berries, often edible, and containing many seeds.

All species are restricted to the cool, temperate regions of the Northern Hemisphere, or to the Andes as far south as Patagonia. However, at least half of the species have been introduced into cultivation and distributed far beyond their natural ranges. The majority are represented only in botanic gardens, but a few species are grown commercially for their fruit, flowers, or foliage.

Economically Important Species. A full bibliography of the literature on *Ribes* crops has been published by Knight and Keep (1958), and only brief mention is made here of the origins of the principal fruits and of the breeding work in progress at several centres.

The American gooseberry varieties are derived from *Ribes hirtellum* Michx., *R. missouriense* Nutt., and related species, whereas the European varieties are developed from *R. grossularia* L. = *Grossularia uvacrispa* (L.) Sm. Many cultivars are grown, differing considerably in size, colour, and pubescence of the fruit. Gooseberries have been hybridized with *R. oxyacanthoides* L. and *R. nigrum* L. to obtain spineless varieties that are resistant to powdery mildew, *Sphaerotheca mors-uvae* (Schw.) Berk.

Commercial black currant varieties are derived from wild forms of *Ribes nigrum* L. that occur from Europe to central Asia and the Himalayas. Hybrids have been made with *R. dikuscha* Fisch., *R. ussuriense* Jancz., *R. aureum* Pursh, and *R. grossularia* L. to increase winter hardiness, content of vitamin C, resistance to drought, the black currant gall mite, *Phytoptus ribis* Nal., and leaf spot, *Pseudopeziza ribis* Kleb.

The cultivated red currant varieties are usually attributed to the northern red currant, *R. rubrum* L. However, *R. sativum* Syme (= *R. vulgare* Lam.) and *R. petraeum* Wulf. are involved in the parentage of many old varieties, and some recent varieties have been developed from *R. multiflorum* Kit. and *R. warscewiczii* Jancz.

The alpine currant, *Ribes alpinum* L., is grown in Europe and North America to form hedges and specimen bushes that thrive in dense shade. There is considerable trade in rooted cuttings, and annually many thousands are grown in the Netherlands and certified for export to Canada and elsewhere.

Four other species are widely grown in Europe and North America for their attractive spring flowers. *R. sanguineum* Pursh and the closely related *R. glutinosum* Benth. have pink or red flowers. The golden currant, *R. aureum* Pursh, and the closely related buffalo currant, *R. odoratum* Wendl., have fragrant bright-yellow flowers, and are also grown to provide fruit in parts of Russia. In addition, *R. aureum* and *R. divaricatum* Dougl. are used in Czechoslovakia, Scandinavia, and Germany as rootstocks for gooseberry.

Distribution and Importance. Currants and gooseberries are widely grown in gardens and smallholdings in many European countries, and wild bushes are exploited in eastern Europe. The main areas of commercial fruit production are in Czechoslovakia, England, France, Germany, the Netherlands, Norway, and Poland. The relative importance of the different crops differs in various countries.

Black currants are pre-eminent in England, with much smaller areas of gooseberries and a few red currants. Elsewhere, red currants tend to be more widely grown than either black currants or gooseberries.

Ribes crops are unimportant outside Europe, although there are a few plantations in New Zealand and Tasmania. Some red currants and gooseberries are also grown in the United States and Canada, but black currants in North America are virtually restricted to British Columbia. Elsewhere they are prohibited because they are the principal alternate host of the five-needled pine rust, *Cronartium ribicola* Dietr.

In many countries, fruit is bought by manufacturers on long- or short-term contracts for canning, confectionery, jam, jelly, juice, pectin production, or pie fillings. Demand fluctuates considerably between seasons, and yields are notoriously subject to spring frosts. This causes exaggerated changes in market prices and crop acreages. Indeed, English black currant crops have in recent years fluctuated by as much as 13 per cent in area between successive seasons, and this has affected disease control. When there is a great demand for fruit and prices are high, the number of certified bushes that are available for planting may be insufficient, and there is a ready sale for substandard material. Moreover, old plantations are retained even when they contain many diseased plants, and would be uneconomic if prices were less favourable. Cross-contamination is facilitated, although there is a stronger incentive to apply chemical control measures than when prices are low.

Aphids of Currants and Gooseberries. Infestations of aphids are common on unsprayed currant and gooseberry bushes in spring and early summer, and the 8 species that occur on the aerial parts are virus vectors (table 4). Populations increase rapidly after the eggs hatch in early spring, and alatae develop after a few generations of apterae. The alatae of 6 species then migrate to herbaceous hosts that have little taxonomic affinity with the *Ribes* species. The return migration to currants and gooseberries occurs in late autumn, and the aphids overwinter as eggs on shoots or buds.

Aphis grossulariae Kalt., *A. schneideri* Börn., and atypical forms or subspecies of *Cryptomyzus galeopsidis* Kalt. and *C. ribis* L. remain on currants or gooseberries throughout the year. The full implications of these different migration patterns in the

TABLE 4

The Principal Aphids Infesting Currant and Gooseberry*

Species	Winter host	Summer host	Vector of: CMV†	Vector of: VB‡
Aphis grossulariae Kalt.	Red currant Gooseberry	Red currant Gooseberry [*Epilobium*]	+	G, R
Aphis schneideri Börn.	Black currant Red currant	Black currant Red currant	+	G, R
[*Aphis triglochinis* Theob.]	Red currant	Cruciferae		R
Cryptomyzus galeopsidis Kalt. and var. *citrinus*	Red currant Black currant	Labiatae: *Lamium*, etc.	+	R
Cryptomyzus ribis L.	Red currant [Black currant]	Labiatae: *Stachys*, etc.	+	R
Hyperomyzus lactucae L.	Black currant [Red currant]	Compositae: *Sonchus* spp.	+	R
[*Hyperomyzus pallidus* (H.R.L.)]	Gooseberry	*Sonchus arvensis* L.		G, R
Nasonovia ribis-nigri (Mosley)	Gooseberry [Red currant] [Black currant]	Compositae: *Hieracium* spp., *Cichorium* spp., etc.	+	G, R

*Minor pests and hosts in brackets. Plus sign (where used) equals "vector."
†Cucumber mosaic virus (CMV).
‡Isolates of vein banding virus from gooseberry (G) or red currant (R).

TABLE 5
The Viruses Infecting *Ribes* Crops

Vectors and viruses	Host plants infected: Naturally	Host plants infected: Experimentally	Indicator plants: Herbaceous†	Indicator plants: Woody
VECTORS: APHIDS				
Cucumber mosaic*, ‡	Black currant *Ribes aureum* Red currant	Gooseberry	*C. amaranticolor* (L) *C. quinoa* (L) *N. tabacum* (S)	Black currant Amos Black
Lucerne mosaic*, ‡		Gooseberry	*C. amaranticolor* (S) *C. quinoa* (S) *N. tabacum* (S)	
Vein banding	Black currant Gooseberry Red currant	*Ribes aureum*		Black currant Amos Black Seedlings of Leveller gooseberry Seedlings of Jonkheer van Tets red currant
VECTOR: ERIOPHYID MITE				
Reversion	Black currant *Ribes "carrierii"* *Ribes rubrum* var. *pubescens* *Ribes bracteosum*	Red currant *Ribes aureum* *Ribes sanguineum*		Black currant Baldwin
VECTORS: NEMATODES				
Arabis mosaic*, ‡	Black currant Red currant	*Ribes aureum* *Ribes sanguineum* Gooseberry	*C. amaranticolor* (S) *C. quinoa* (S) *N. tabacum* (S)	Black currant Amos Black
Raspberry ringspot*, ‡	Gooseberry Red currant *Ribes sanguineum*	Black currant	*C. amaranticolor* (L) *C. quinoa* (S) *N. tabacum* (S)	Black currant Amos Black Red currant Clenonceau
Strawberry latent ringspot*, ‡	Black currant Red currant		*C. amaranticolor* (S) *C. quinoa* (S) *N. tabacum* (S)	
Tomato ringspot*, ‡ (American currant mosaic)	Red currant		*C. amaranticolor* (S) *C. quinoa* (S) *N. tabacum* (S)	Red currant seedlings
VECTOR UNKNOWN				
Black currant yellows	Black currant			Black currant seedlings
Infectious variegation	Black currant			Black currant seedlings
Interveinal white mosaic*	Red currant	Black currant *Ribes sanguineum*	*C. amaranticolor* (S) *C. quinoa* (S) *N. rustica* (S)	Red currant Fay's Prolific or Laxton's No. 1
Leaf pattern*	Red currant		*N. tabacum* (L) *N. rustica* (L) *C. quinoa* (L)	
Yellow leaf spot (European currant mosaic)	Red currant			Red currant Laxton's No. 1

*Virus sap-transmissible to herbaceous indicator plants that are infected locally (L) or systemically (S).
†Species of *Chenopodium* (*C.*) or *Nicotiana* (*N.*).
‡This symbol means "antiserum available," in addition to the meaning of the asterisk which it follows.

epidemiology of vein banding and cucumber mosaic viruses have yet to be established.

Severe aphid infestations cause considerable stunting of the shoots, with twisting and distortion of the leaves. Several species also produce phytotoxic secretions that may be translocated to uninfested leaves and cause symptoms resembling those of the vein banding virus. Direct feeding damage is usually apparent from the aphids, honeydew, or cast skins present on affected or adjacent leaves. Damage can be distinguished from virus symptoms less readily when noticed after the aphids have dispersed or have been eradicated by sprays or predators. In graft-transmission experiments, it is essential to avoid the complicating effects of aphids spreading virus or causing direct damage. Aphids used in transmission experiments should be destroyed immediately after the requisite feeding period.

Traditional tar-oil winter washes that destroy overwintering eggs have obvious advantages in preventing virus spread, and are recommended to control aphids. Additional applications of systemics eradicate the infestations of *Aphis* species that develop on nursery stocks in summer.

The Viruses Occurring. The main commercial varieties of currants and gooseberries were introduced into Britain, Denmark, France, Germany, the Netherlands, Sweden, and the United States. Many of them have been grown widely for many years, with much interchange of material between countries.

There has been plenty of opportunity for viruses to accumulate, and a diverse group of at least 13 apparently distinct viruses is presently known. Several viruses affect more than one of the *Ribes* crops (table 5).

Little attention has been given to the virus diseases occurring in many countries, and inevitably the available information underestimates the distribution of the known viruses. Other viruses may have been overlooked entirely, because of inadequacies in present indexing procedures.

Clearly, there are grave hazards in importing plants from some countries, and present quarantine arrangements have serious limitations. This justifies a cautious approach to the introduction of species and varieties for commerce, for botanic gardens, and for plant breeding. It is advantageous to keep imported material well isolated from other bushes in an attempt to decrease the risk of introducing new viruses or virus strains. The ability to detect certain viruses by sap transmission from dormant buds to herbaceous hosts provides a means of intercepting some infected consignments.

Economic Significance. Any assessment of the economic effects of virus infection in *Ribes* crops will be premature until more information is available on the distribution of the different viruses and on the sensitivity of the main commercial varieties.

Present indications are that reversion is the only important virus disease of black currant. In many countries, infection is spread rapidly by the gall-mite vector, and control measures are necessary to avoid serious losses.

Vein banding seems to be the only important virus disease of gooseberry and red currant. It is spread slowly by the aphid vectors, but commercial stocks of many old varieties are totally infected, and yields must be considerably reduced.

Virus Techniques. Various grafting methods have been used successfully to transmit viruses between *Ribes* plants, but techniques that do not involve buds are recommended to avoid transferring eriophyid mites that damage growth and cause virus-like symptoms. Excellent results have been obtained by using patches of bark in June, July, and August, with strips of rubber or plastic to hold the patches in position.

Somewhat earlier in the season, when working with young seedlings, virus can be transferred in scions of unhardened green stem tissue bound by self-adhesive bandages.

None of the viruses infecting *Ribes* plants have been transferred between bushes by sap inoculation. However, 8 viruses have been transmitted to herbaceous hosts, from which 5 of the viruses have been returned to currant and gooseberry seedlings by sap inoculation.

Preparations made by macerating the leaves or dormant buds of *Ribes* plants in water or buffer are usually of low infectivity, whereas preparations made with 5 times the weight of 1 or 2 per cent nicotine base are highly infectious when inoculated with an abrasive to susceptible herbaceous plants.

In sap- and aphid-transmission experiments involving currant and gooseberry, the best results are obtained by inoculating very young seedlings. A continuous succession is ensured by extracting the seed at harvest and sowing immediately in trays of soil stored at 1° C. and withdrawn as required. Another method: Seed may be mixed with sand or peat and kept in a refrigerator. Seed germinates unsatisfactorily unless treated for several weeks at low temperatures.

There appear to have been no attempts to transmit viruses or to from *Ribes* plants by dodder, and no reference to this technique is made in the separate description of each disease.

Certification. In several countries, certification schemes have been introduced to improve the general standard of planting material. Bushes are inspected and certified if sufficiently vigorous, true to type, and not seriously affected by pests or diseases. In black currant, particular attention is given to reversion disease, and there may be additional winter inspections for galls caused by the mite vector. Bushes must also be isolated from uncertified stocks.

In the Netherlands, certified stocks are grown from cuttings supplied by the official NAK B organization and raised under contract on isolated farms in North Holland. Specially selected and tested bushes provide the basic material. A similar arrangement operates in England, where the basic stocks are propagated in East Anglia, away from main production areas.

Indexing. Formerly, the best available stocks were selected by experienced inspectors, who merely eliminated bushes with conspicuous symptoms. Latent infection and inconspicuous or unfamiliar symptoms were overlooked, and indexing procedures are now being developed to improve the selection procedure. Sap inoculation to herbaceous hosts is quick, convenient, and effective with several viruses. Others can be diagnosed only after graft inoculation to sensitive woody hosts, with an inevitable delay of several months between inoculation and symptom expression (table 5).

Antisera are available to 6 of the sap-transmissible viruses listed in table 5. This simplifies their identification, and is invaluable in distinguishing between certain NEPO viruses that have a similar host range and similar properties *in vitro*. Double diffusion tests in agar gel use little serum and are convenient for routine diagnosis, even when many samples are involved. Visible precipitates form overnight at room temperature, and specific lines may be distinguished if appropriate controls have been included in the tests.

Leaf Malformation of Gooseberry

J. M. Thresh

Gooseberry bushes with malformed leaves and dieback have been found at various localities in Scotland (Gray, 1949; Gray and Everett, 1956). Preliminary tests with material from one source suggested that the condition was graft-transmissible to healthy gooseberries. No further investigations have been reported, and there were no attempts to isolate raspberry ringspot virus. (See the *Rubus* section.)

A somewhat similar condition referred to as "claw leaf" or "hawthorn leaf" (figure 44) has been found in England affecting several varieties at the National Fruit Trials in Kent and in the important gooseberry-growing area around Wisbech.* Raspberry ringspot virus was not isolated from affected bushes, and graft tests are in progress. There is no evidence of spread between bushes, but some stocks are more seriously affected than others.

*Isle of Ely county, northern Cambridge.

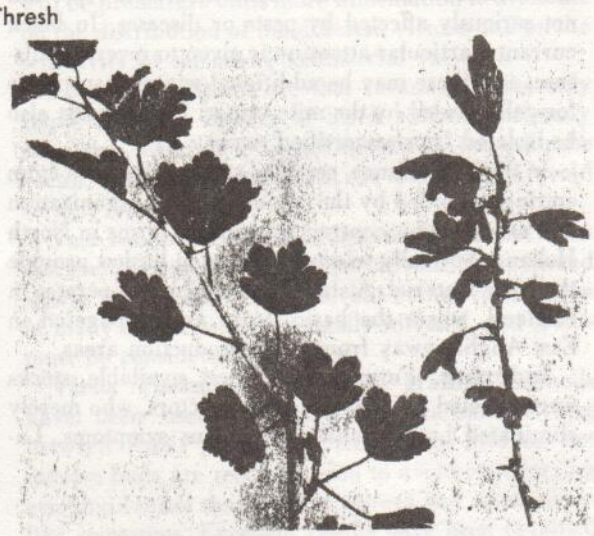

Fig. 44. Right: Leaf malformation of gooseberry. Left: Healthy shoot.

Reversion of Black Currant

J. M. Thresh

Other Common Names. Atavismus; zvrát černého rybízu.

History and Geographical Distribution. Reversion disease was first described in the Netherlands and England between 1904 and 1912. By that time, it was common in gardens and plantations, usually associated with outbreaks of the black currant gall mite (*Phytoptus ribis* Nal.) that had long been known as a serious pest of black currant bushes. The direct damage caused by the mite was at first confused with the effects of the virus it transmits. This is because reversion virus and its vector have a complex and unique interrelationship on their black currant host (Thresh, 1964).

Reversion has been recorded in virtually all the countries where black currants are grown. Infection is rare in New Zealand, Australia, and British Columbia, but widespread and prevalent in most European countries. The disease has increased in importance in recent years in Austria, Germany, Poland, and Switzerland, where previously it was rare.

Economic Importance. Reversion is the most important disease affecting black currant in Britain and some other European countries, and its effects on crops are drastic. Reversion is a potential threat in all other producing countries.

Host Range. Black currant is the usual host of reversion virus, but it has been recovered also from naturally infected *Ribes bracteosum* Dougl., *R. rubrum* L. var. *pubescens* Swartz, and *R. "carrierii"* (*R. glutinosum* Benth. × *R. nigrum* L.). Several other species and hybrids have been infected by graft inoculation, but none have given more conspicuous symptoms than black currant.

All the main commercial black currant varieties are susceptible, although there are slight differences in their resistance to mite infestation and in their tolerance to virus infection. The significance of the main commercial red currant varieties as hosts of mites and virus is still uncertain, but they seem immune to the usual strains.

Symptoms. Symptoms in black currant do not appear until the year after inoculation, and they are at first restricted to one or a few shoots. One-third to one-half of the bush is affected in the second year, and infection is fully systemic by the third or fourth year. The habit of growth is affected, together with specific effects on the flowers and leaves.

a) Infection decreases the number and size of the primary leaves that subtend flowers, and leaves produced during the blossom period are chlorotic. There is little difference in the amount or colour of the later extension growth, although the shoots of healthy bushes tend to be fewer and longer than those of reverted bushes. These differences are not sufficiently great or constant for routine diagnosis.

b) The common strains of virus occurring in Britain and many other European countries decrease the hairiness of the sepals, so that the flower buds are almost glabrous and appear brightly coloured, compared with the grey, downy appearance of normal buds (figure 45). The difference is readily apparent unless the bushes are wet or infected with an unusually avirulent strain.

In Russia, Scandinavia, and some other countries, the flowers of reverted bushes are glabrous and also severely malformed, with the style elongated and the stamens replaced by additional petals. These "double" flowers seem to be caused by a particular strain of virus that is uncommon in Britain and western Europe.

c) Infected bushes develop leaves that are flatter than normal and have a smaller basal sinus. Infection also decreases the number of main veins and marginal serrations (figure 46, center. Compare with normal leaf at left). After some experience, these differences can be used for accurate diagnosis in May, June, or July, when attention should be given only to leaves on undamaged shoots of the extension growth. Forked shoots and those damaged mechanically or by capsid (mirid) bugs and other insects develop atypical leaves. A further complication is that there are inherent differences between the leaves of certain varieties.

d) Leaves that are invaded by some strains of reversion virus develop a nonrecurring vein pattern (figure 46, right). This is of limited value in diagnosis, as symptoms are often slight and restricted to a few inaccessible leaves that may be concealed by later growth.

Symptoms of infectious variegation and those of a somewhat similar condition in other varieties are particularly severe when bushes are also affected by reversion.

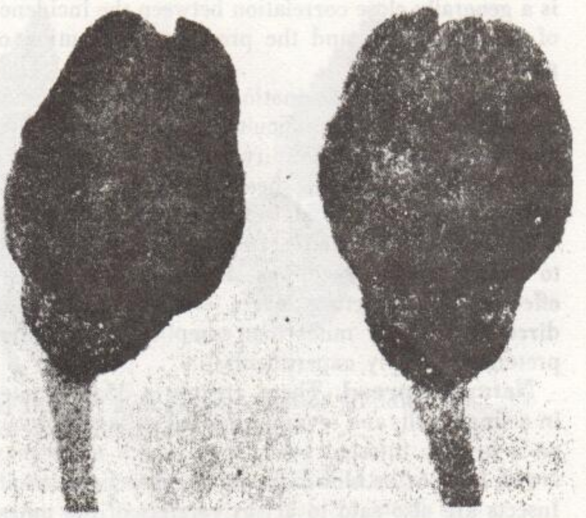

Fig. 45. Left: Glabrous flower bud of black currant with reversion. Right: Hirsute bud of healthy bush.

Cause. There is no information on the properties of reversion virus.

Transmission. Reversion is readily transmitted by various grafting methods, but some are unsuitable because the mite vector could be transferred in buds taken from the infected source. This risk is avoided by using patch grafts. Reversion virus has not been transmitted by pollen, seed, or sap.

Recent experiments have confirmed the early evidence implicating the black currant gall mite as the vector of reversion. The virus is transmitted efficiently during the late spring and early summer, when mites disperse from the old galls to the buds of the new growth. There is no further spread until the following year, and mites remain within infested buds that fail to develop flowers or leaves and become rounded galls (Thresh, 1965). Virus symptoms do not develop until the year after infestation, and there

Fig. 46. Left: Normal leaf of black currant. Center and right: Leaves affected by reversion.

is a generally close correlation between the incidence of virus infection and the previous distribution of galls.

There is little information on the transmission process, owing to the difficulty of transferring mites and their apparent inability to feed except within galls or buds. Virus has been transmitted by single mites and by mites that were eradicated by endrin 4 hours after they had been transferred from galls to healthy young seedlings. Endrin is particularly effective in protecting leaves and buds from the direct damage by mites that complicated the interpretation of early experiments.

Natural Spread. There are up to 35,000 mites in a single gall, and several hundred galls may occur on a heavily infested bush, from which mites may crawl, leap, or be blown during the dispersal period. Insects are also said to act as carriers of the mites, and much spread may occur to plants growing considerable distances from large sources of infection (Thresh, 1966*a*). An additional feature of crucial importance in epidemiology is that the resistance of healthy black currant bushes to mites is diminished by infection with reversion. It is hardly surprising, therefore, that reversion is such a widespread and successful pathogen, with an unusually rapid rate of spread for a virus disease of a woody perennial such as the black currant.

Control Measures. Bushes offered for sale may have been propagated from an infected source, and some of the buds may be infested with mites. These possibilities should be appreciated, and stringent quarantine restrictions should be enforced to avoid disseminating mites and additional infection or further virus strains to countries that previously had been little affected.

In countries where reversion occurs, new plantations should be established with bushes or cuttings from a good stock that is free of infection. Planting should be done upwind and at least 90 m away from any seriously contaminated holdings in the area, and routine treatments with effective acaricides should be used. Moreover, the bushes should be inspected annually just before flowering begins, and again in May or June, to diagnose and remove infected bushes as they occur. These measures are interdependent to a large extent, and all must be adopted for full effectiveness.

Therapy. Reverted bushes grown for 20 to 30 days at 37° C. developed symptomless leaves, but symptoms recurred on the later growth made at normal temperatures. Shoot tips remained healthy when detached from treated plants, and took root (Campbell, 1965).

Detection and Identification. Diagnosis depends upon the ability to recognize the characteristic effects of reversion on flowers or leaves. If growth is damaged or malformed and the symptoms are indistinct, suspect material should be used to graft-inoculate 1-year-old Baldwin bushes. This widely grown variety is sensitive to infection, and consistently produces uniform growth in which any symptoms will be readily apparent the following year.

Vein Clearing and Vein Net of Black Currant

J. M. Thresh

Other Common Names. None.

History and Geographical Distribution. Vein-clearing and vein-net diseases of black currant have only recently been described and attributed to infection with gooseberry vein banding virus (Thresh, 1966*b*). This is widespread in gooseberry, and may cause the equally prevalent vein banding of red currant. However, infected black currant bushes have not been reported outside Britain, where only occasional infected ones have been found in nurseries or bearing plantations at various localities.

Economic Importance. Infection does not appear to be sufficiently widespread to cause serious economic losses. Infected bushes are only slightly stunted, and carry almost a full crop.

Host Range. All the principal commercial varieties of black currant are susceptible to graft inoculation. They differ greatly in tolerance to infection, and Baldwin and Wellington XXX, the main commercial varieties grown in Britain, rarely develop symptoms. Amos Black and Westwick Triumph are particularly sensitive, but the latter is not recommended for use as an indicator because it grows slowly.

Gooseberry is susceptible to graft inoculation, and develops typical vein banding. Red currant has yet to be inoculated, although black currant develops typical vein clearing on infection with red currant or gooseberry vein banding.

Symptoms. Sensitive black currant varieties develop a broad yellow banding and occasional clearing of the main veins of the first-formed leaves that subtend flowers (figure 47, left). Later leaves develop a clearing and narrow yellow banding of the main veins. Entire leaves of Mendip Cross are affected in May and June with a vein net pattern

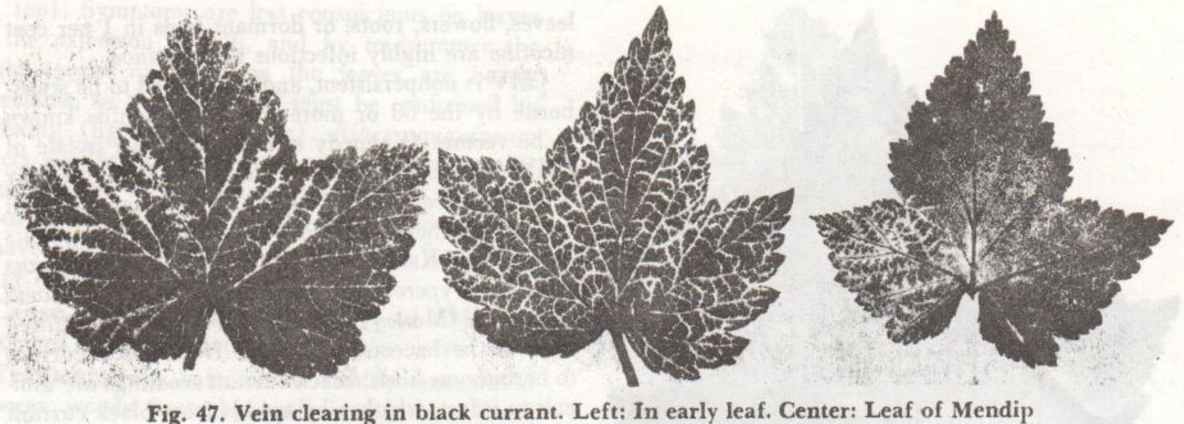

Fig. 47. Vein clearing in black currant. Left: In early leaf. Center: Leaf of Mendip Cross in midsummer. Right: Leaf of Amos Black in midsummer.

(figure 47, center). Symptoms in other varieties, such as Amos Black, are often restricted to individual lobes of occasional leaves that become slightly distorted and asymmetrical (figure 47, right).

Cause. There is no information on the morphology or properties *in vitro* of the causal virus.

Transmission. The virus is readily transmitted by graft inoculation, and black currant seedlings have been infected by aphids, *Nasonovia ribis-nigri* (Mosley), transferred from gooseberries with vein banding (Posnette, 1964). There have been no experiments with sap inoculation.

Natural Spread. Infection in black currant nurseries and plantations spreads slowly, presumably by *N. ribis-nigri* and other aphids that transmit gooseberry vein banding virus (table 4, page 76).

Control Measures. Infected bushes should be found and removed during the routine inspections for reversion. Spread is likely to be slow if healthy stocks are planted and aphids are controlled efficiently.

Detection and Identification. Infection in sensitive varieties can be diagnosed without difficulty in April, May, or June, provided that aphids have not been allowed to distort the growth and cause phytotoxicity. In tolerant varieties or late in the season, suspected bushes should be indexed by graft inoculation to the sensitive Amos Black variety.

Green Mottle of Black Currant

J. M. Thresh

Other Common Names. None.

History and Geographical Distribution. Green mottle of black currant is caused by cucumber mosaic virus (CMV), a cosmopolitan pathogen with an unusually wide host range. Infection in black currant has been reported only recently in a few bushes in each of several plantations or nurseries in England and Wales (Thresh, 1966*b*).

Economic Importance. Infected bushes are stunted and bear little crop, but infection does not seem to spread rapidly between black currant bushes, and the disease is not sufficiently widespread to be of economic importance.

Host Range. All the main commercial varieties of black currant are susceptible and develop similar symptoms, but there are differences in tolerance. Amos Black is particularly sensitive, and is recommended as an indicator.

CMV also causes a green-mottle disease of red currant and an "arc mosaic" of the golden currant (*Ribes aureum* Pursh) in Germany (Schmelzer, 1963). Many other weed and cultivated plants are susceptible, including many of the standard herbaceous hosts used in diagnosis of virus diseases.

Symptoms. Small, rapidly growing black currant seedlings develop symptoms 3 or 4 weeks after inoculation. Established bushes do not produce symptoms until the following year, when they are often restricted to the inoculated shoots and those near-by. Symptoms are very variable. They are seen best as the leaves become fully expanded, and tend to be inconspicuous in young and senescing leaves. Large sectors of some leaves become pale green (figure 48). At other times, discolouration is restricted to broad bands along certain main veins, sometimes giving a "watermark" effect that is best seen by transmitted light.

CMV is the only sap-transmissible virus of *Ribes* crops that infects tobacco systemically and causes only primary symptoms in both *Chenopodium ama-*

Fig. 48. Leaf of black currant with symptoms of green mottle.

ranticolor and *C. quinoa*. The latter hosts have proved particularly sensitive to sap inoculation, and develop necrotic local lesions from which the virus may be transmitted to many other species of herbaceous host plants.

Cause. The morphology and properties of CMV are described in the *Rubus* section; see that section's table of contents.

Transmission. Green-mottle disease is readily transmitted by patch grafts and by sap inoculation to herbaceous hosts. Inocula prepared by macerating leaves, flowers, roots, or dormant buds in 1 per cent nicotine are highly infectious to *C. quinoa*.

CMV is nonpersistent, and is assumed to be stylet-borne by the 60 or more species of aphids known to be vectors (Kennedy *et al.*, 1962). An isolate of CMV from black currant has been transmitted by *Myzus persicae* (Sulz.) and 5 species that spend all or part of their life cycles on *Ribes* crops: *Aphis grossulariae* Kalt., *A. schneideri* Börn., *Cryptomyzus ribis* L., *Hyperomyzus lactucae* L., and *Nasonovia ribis-nigri* (Mosley). The virus is readily transmitted between herbaceous hosts and from black currant to herbaceous hosts. Black currant seedlings are difficult to infect, whether by aphids from black currant or herbaceous hosts.

Natural Spread. Symptoms are easily overlooked, and cuttings may be collected unwittingly from infected bushes and then propagated and sold. There is little natural spread within plantations, and infection seems to be carried into the crop from other weed or cultivated hosts; perhaps by aphids that infest black currant temporarily or by chance.

Control Measures. Specific control measures are unnecessary, although routine sprays against aphids should continue, and care should be taken to eliminate infected bushes from nursery stocks and those used for propagation.

Detection and Identification. Suspect bushes can be indexed by sap transmission to *Chenopodium quinoa* and other herbaceous hosts, or by graft inoculation to the Amos Black variety. Tests with buds provide a good opportunity to check the health of dormant bushes and those in transit between countries.

Yellow Mottle of Black Currant

J. M. Thresh

Other Common Names. None.

History and Geographical Distribution. Yellow mottle of black currant is caused by the arabis mosaic virus (AMV). Infection in black currant has been reported only in 1 English nursery, and in a few plantations established with bushes distributed from it.

Economic Importance. Infected bushes produce little fruit, but infection does not seem to be sufficiently widespread to cause serious economic losses.

Host Range. AMV has a wide host range in weeds, herbaceous test plants, and cultivated crops, including raspberry, strawberry, and red currant; for the 2 first-mentioned crops, consult their respective sections.

Isolates from black currant have been graft-transmitted to *Ribes aureum* Pursh, *R. sanguineum* Pursh, and all the black and red currant varieties tested. The various black currant varieties reacted similarly, with no great differences in sensitivity. *Chenopodium amaranticolor* and *C. quinoa* are particularly sensitive to infection by sap inoculation, and within 2 weeks develop local and systemic symptoms that closely resemble those caused by strawberry latent ringspot virus, for which see the strawberry section.

Symptoms. Black currant bushes graft-infected in July or August develop symptoms the following year, when the first-formed leaves show a conspicuous yellow mottle. This may be irregularly distributed, or may form yellow spots and rings (figure

49, top). Symptoms are less conspicuous on leaves of the extension growth, and by midsummer the slight specks or flecks on the leaves are barely detectable, so that diagnosis must be confirmed by indexing (figure 49, bottom). *Ribes sanguineum* reacts similarly, whereas red currant varieties become infected without showing symptoms. In herbaceous hosts, isolates of AMV from black currant behave like the virulent strains obtained from raspberry. (See the *Rubus* section.)

Cause. Properties and morphology of AMV are described in the strawberry section.

Transmission. Infection is readily transmitted between woody hosts by graft inoculation. There have been no experiments with *Xiphinema diversicaudatum* (Micoletsky), the nematode vector of AMV in other crops. Preparations made by macerating leaves or dormant buds with nicotine are highly infectious to herbaceous hosts, from which the virus is transmissible by sap inoculation to black currant seedlings.

Natural Spread. *Xiphinema diversicaudatum* is present in the soil at the infected nursery in England mentioned earlier. It is assumed to be the natural vector, although much spread is caused by the indiscriminate propagation and sale of infected cuttings.

Control Measures. Black currant stock should not be planted at sites where virus and vector are present. Special stocks destined for propagation should be checked to ensure that they are free of infection.

Detection and Identification. Infection is detected most readily by sap inoculation to *Chenopodium quinoa*. Sap from systemically infected plants reacts specifically in agar-gel diffusion tests with antisera that distinguish AMV from other NEPO viruses. These include strawberry latent ringspot virus, which has been recorded once in black currant (Lister, 1964).

Amos Black is a suitable indicator for graft-inoculation experiments, and it is also sensitive to some other viruses of *Ribes* crops, as shown in table 5 on page 77.

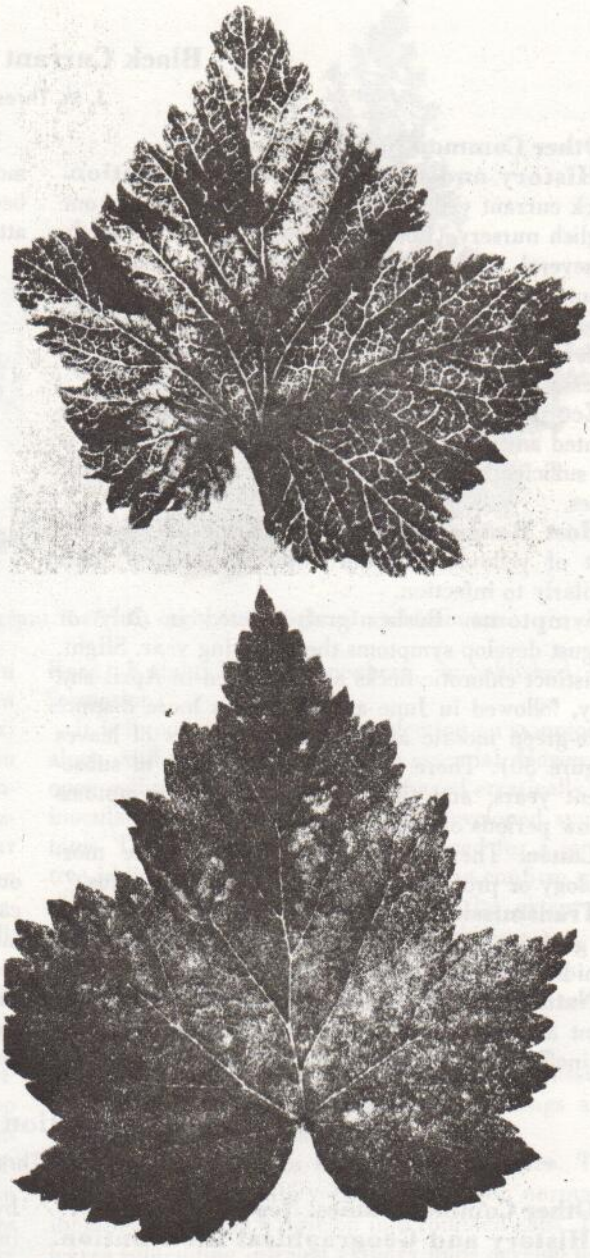

Fig. 49. Leaves of black currant with yellow mottle caused by arabis mosaic virus. Top: In early leaf. Bottom: In midsummer.

Black Currant Yellows

J. M. Thresh

Other Common Names. None.

History and Geographical Distribution. Black currant yellows disease has been found in one English nursery (Posnette, 1952), and subsequently in several plantations established with bushes distributed from it. The disease has not been found in other countries, although the term "yellows" has been applied indiscriminately to other symptoms not necessarily caused by virus infection.

Economic Importance. Infected bushes are stunted and their crop is decreased, but infection is not sufficiently widespread to cause serious economic losses.

Host Range. Black currant is the only known host of yellows, and the different varieties react similarly to infection.

Symptoms. Bushes graft-infected in July or August develop symptoms the following year. Slight, indistinct chlorotic flecks are produced in April and May, followed in June and July by a more distinct olive-green mosaic affecting large sectors of leaves (figure 50). There is a similar sequence in subsequent years, and the most conspicuous symptoms follow periods of warm, sunny weather.

Cause. There is no information on the morphology or properties *in vitro* of the causal virus.

Transmission. Infection is readily transmitted by graft inoculation. Sap inoculations and tests with aphids have been unsuccessful.

Natural Spread. Slow spread in a field experiment at East Malling suggests that there is a rare or inefficient natural vector (Cropley *et al.*, 1964).

Detection and Identification. Yellows may be more widespread than present evidence suggests because the symptoms are easily overlooked or attributed to soil or nutritional disorders. Conspicu-

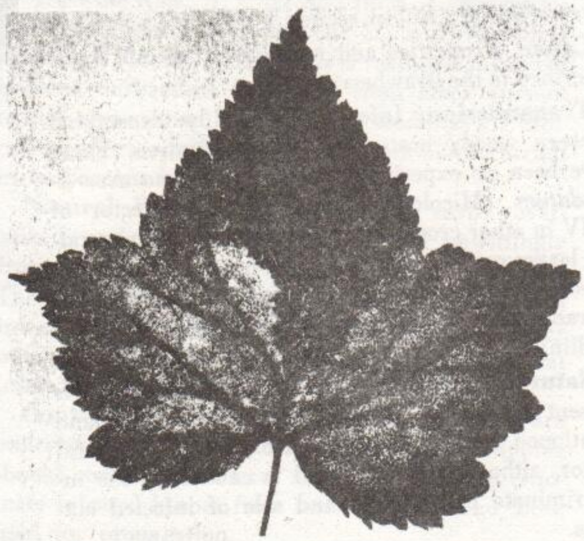

Fig. 50. Symptoms of black currant yellows.

ous symptoms are produced some weeks after those caused by other viruses, and necessitate an additional late inspection at a time when damage by the leaf-spot fungus (*Pseudopeziza ribis* Kleb.) may be prevalent. Preliminary diagnosis can be confirmed by graft transmission to Amos Black or other black currant varieties.

Infectious Variegation of Black Currant

J. M. Thresh

Other Common Names. None.

History and Geographical Distribution. The symptoms of infectious variegation were described (Posnette, 1952) some years before the disease was transmitted (Ellenberger, 1962). Infection occurs throughout the commercial stocks of several little-grown varieties in England. A similar condition has been transmitted in Denmark, and has been noticed in other European countries.

Host Range and Symptoms. Black currant is the only known host, and the sensitive varieties Daniel's September and Laxton's Nigger develop a bright-chrome or pale-yellow mosaic of the early leaves (figure 51, left). This is followed in summer by a broad yellow banding of the main veins, forming a vein net pattern (figure 51, right). Symptoms differ greatly in severity between years.

The common varieties Baldwin and Wellington XXX are highly tolerant, and graft-inoculated plants develop only very slight symptoms in occasional seasons.

Cause. There is no information on the morphology or properties *in vitro* of the causal virus.

Transmission. Infection has been transmitted only by graft inoculation to certain black currant seedlings or varieties.

There have been no experiments on sap inoculation or with insects.

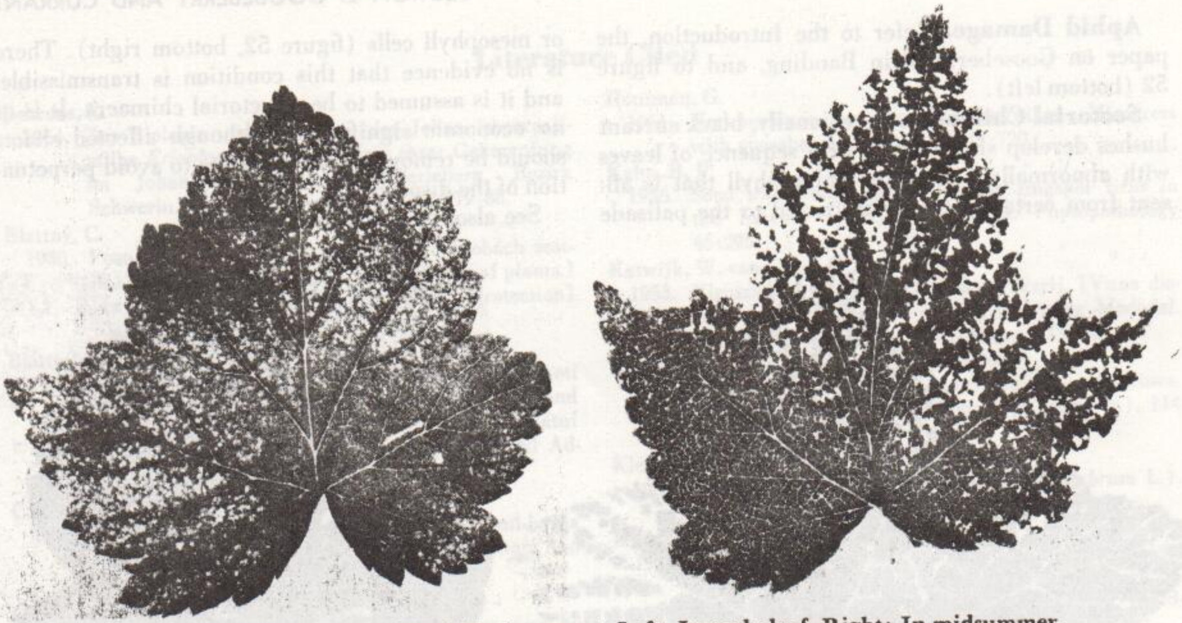

Fig. 51. Infectious variegation of black currant. Left: In early leaf. Right: In midsummer.

Detection and Identification. Seedlings grown at East Malling and at Wageningen from certain black currant crosses have developed symptoms exactly resembling those of infectious variegation in Daniel's September. Seedlings grown at Long Ashton and Dundee from imported Scandinavian or Russian material have also developed somewhat similar symptoms. In all instances, the seedling condition was apparently not graft-transmissible, and is assumed to have been inherited (Anderson, Campbell, Keep, Knight, and Kronenberg, unpublished information).

It is impossible to diagnose infection on symptoms alone, and transmission tests are essential. However, open-pollinated seedlings have behaved erratically on inoculation, and only a part have developed symptoms. There is therefore an urgent need for a sensitive indicator clone that can be used to confirm previous investigations and determine the extent of infection in the main commercial varieties.

Viruslike Disorders of Black Currant

J. M. Thresh

Spring Vein Banding. In early spring, the first-formed leaves of fruiting bushes sometimes develop a yellow banding of the main veins that is very conspicuous in certain years (figure 52, top left). Affected leaves usually subtend flowers, and soon abscise. Symptoms rarely develop on nursery bushes or on the leaves of the extension growth, and are missed unless the bushes are inspected as soon as flowering begins.

The symptoms have been seen in many varieties and attributed to damage by cold winds, but are much more likely to be caused by virus infection. The symptoms in black currant are apparently distinct from those of gooseberry vein banding virus, and occur only in some clones of certain varieties.

Transmission experiments have been hampered by the lack of suitable indicators. Young seedlings have been inoculated, but they must be kept for at least 2 years for flowers to develop. Results of transmission tests to red currant and gooseberry seedlings and varieties are not yet available.

Damage to Leaves by Eriophyid Mites. The black currant gall-mite vector of reversion normally inhabits buds, which develop into rounded galls. The leaves subtending infested axillary buds develop normally, but leaves produced after an apical bud has become infested are severely malformed, and ultimately, almost trifoliate leaves appear (figure 52, top right).

Reverted bushes are much more susceptible to mites than healthy ones, and malformation tends to be associated with virus infection. This explains why distorted trifoliate leaves were long considered to be the ultimate stage of reversion. However, virus infection affects the shape and venation of leaves without affecting their bilateral symmetry. *(Continued.)*

Aphid Damage. Refer to the Introduction, the paper on Gooseberry Vein Banding, and to figure 52 (bottom left).

Sectorial Chimaera. Occasionally, black currant bushes develop single leaves or a sequence of leaves with abnormally distributed chlorophyll that is absent from certain lobes or restricted to the palisade or mesophyll cells (figure 52, bottom right). There is no evidence that this condition is transmissible, and it is assumed to be a sectorial chimaera. It is of no economic significance, although affected shoots should be removed from nurseries to avoid perpetuation of the disorder.

See also, page 255, section 5.

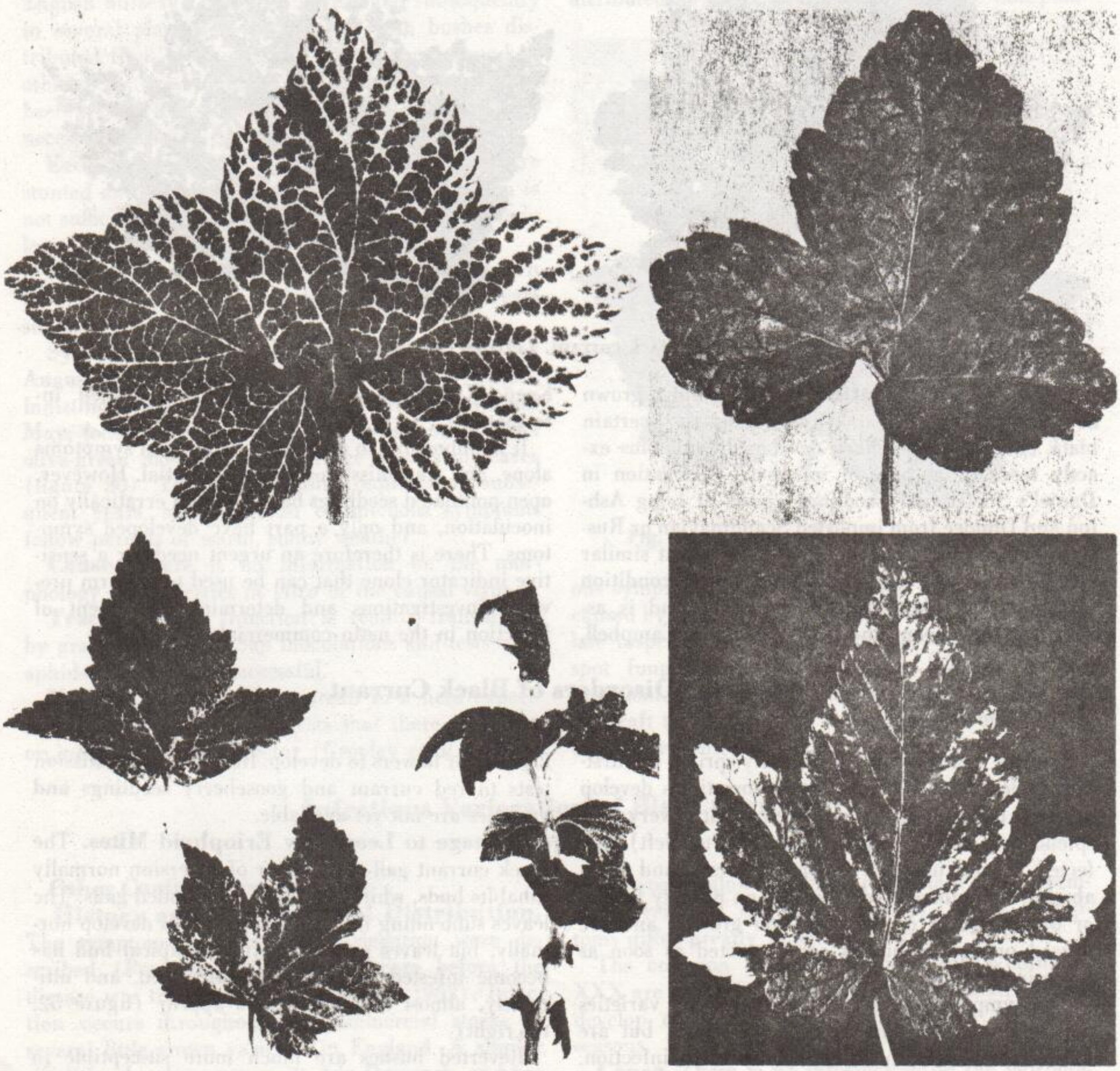

Fig. 52. (Black currant.) Top left: Spring vein banding. Top right: Damage by mites. Bottom left: Damage by phytotoxic secretions of aphids. Bottom right: Sectorial chimaera.

Literature Cited

Behrens, E.
1964. Zur Biologie und Oekologie der Johannisbeergallmilbe *Eriophyes ribis* Nal. sowie ihrer Gekampfung im Johannisbeeranbaugebiet Perleberg, Bezirk Schwerin. Wiss. Z. Univ. Rostock 13:279–88.

Blattný, C.
1930. Poznámky o virových a příbuzných chorobách rostlin. [Studies on virus and related diseases of plants.] [In Czech.] Ochrana Rostlin [Plant Protection] 10:130.

Blattný, C., and K. Paulechová
1964. Ochrana ovocných stromů, keřů, a révy vinné proti virozám. [Protection of fruit trees, small fruits, and grapevines against viruses.] [In Czech.] Státní Zemědělské Nakladatelství [State Agricultural Administration], Prague. Pages 76–84.

Cadman, C. H.
1960. Studies on the relationship between soil-borne viruses of the ringspot type occurring in Britain and continental Europe. Virology 11:653–64.

Campbell, A. I.
1965. The inactivation of black currant reversion virus by heat therapy. Long Ashton Research Station, Report for 1964, p. 89.

Cropley, R., A. F. Posnette, and J. M. Thresh
1964. The effect of black currant yellows virus and a strain of reversion on yield. Ann. Appl. Biol. 54:177.

Dijksterhuis, H. P.
1950. Afwijkende verschijnselen in rode bessen welke aan virusaantasting doen danken. [Various symptoms in red currant owing to virus attack.] Tuinbouwberichten 5:157.

Ellenberger, Christina E.
1962. Transmission of variegation in black currants. East Malling Research Station, Report for 1961, p. 101.

Gray, E. G.
1949. An interesting disease of gooseberries. Gardeners' Chron. 125:198.

Gray, E. G., and H. F. Everett
1956. Serious breakdown of gooseberries. Gardeners' Chron. 140:403.

Harrison, B. D.
1961. Identity of red currant spoon-leaf virus. Tijdschr. Plantenziekten 67:562.

Hildebrand, E. M.
1939. Currant mosaic. Phytopathology 29:369.
1942. Tomato ringspot on currant. Amer. Jour. Bot. 29:362.

Hildebrand, E. M., and P. V. Weber
1944. Varietal susceptibility of currants to cane blight organisms and to currant mosaic virus. Plant Disease Reptr. 28:1031.

Hille Ris Lambers, D.
1949. Contributions to a monograph of the Aphididae of Europe. IV. Temminckia 8:182.
1953. Contributions to a monograph of the Aphididae of Europe. V. Temminckia 9:1.

Holmes, F. O.
1939. Handbook of phytopathogenic viruses. Burgess Publishing Co., Minneapolis. 221 pages.

Houtman, G.
1951. Het verlopen van kruisbessenstruiken. [Progress with gooseberries.] Fruitteelt 41:720.

Kahn, R. P.
1956. Seed transmission of the tomato ringspot virus in the Lincoln variety of soybean. Phytopathology 46:295.

Katwijk, W. van
1953. Virusziekten in de vruchtboomkwekerij. [Virus diseases in the fruit tree nursery.] Verslag Mededel. Plantenziekten Dienst (Wageningen) 119:22.

Kennedy, J. S., M. F. Day, and V. F. Eastop
1962. A conspectus of aphids as vectors of plant viruses. Commonwealth Inst. of Entomology (London). 114 pages.

Klesser, P. J.
1951. A virus disease of red currant (*Ribes rubrum* L.). Ann. Appl. Biol. 38:707.

Knight, R. L., and E. Keep
1958. Abstract bibliography on breeding and genetics of *Rubus* and *Ribes*. Commonwealth Bureau of Horticultural and Plantation Crops, East Malling, Maidstone, Kent. Tech. Commun. No. 25.

Lister, R. M.
1964. Strawberry latent ringspot: A new nematode-borne virus. Ann. Appl. Biol. 54:167–76.

Maarse, J.
1926. Een nieuwe afwijking in de "Fay's Prolific" en een raadgeving aan kwekers en telers. [A new (virus) deviation in Fay's Prolific, and advice to nurserymen and growers.] Floralia 41:473.
1936. Hoe werken we de knoploosheid zoveel mogelijk uit de Fay's Prolificstruiken? [How much can we possibly do to eradicate budlessness from Fay's Prolific bushes?] Fruitteelt 26:5–6.
1938. Lepelblad bij rode bessen. [Spoon leaf in red currant.] Fruitteelt 28:311.

Maat, D. Z.
1965. Serological differences between red currant spoonleaf virus, virus isolates from echelrade-diseased cherry trees, and Scottish raspberry ringspot virus. Neth. Jour. Plant Pathol. 71:47.

Maat, D. Z., F. A. van der Meer, and H. J. Pfaeltzer
1962. Serological identification of some soil-borne viruses causing diseases of fruit crops in the Netherlands. Tijdschr. Plantenziekten 68:120.

Meer, F. A. van der
1960. Onderzoekingen betreffende bessevirussen in Nederland. I. Lepelblad van rode bes. [Investigations of currant viruses in the Netherlands. I. Spoon leaf of red currant.] Tijdschr. Plantenziekten 66:12.
1961. Virusziekten bij rode bessen. [Virus diseases in red currants.] Fruitteelt 51:166.
1962. Jaarverslag 1962, Inst. Plantenziekten Onderz., p. 92.
1965. Investigations of currant viruses in the Netherlands. II. Further observations on spoon-leaf virus, a soilborne virus transmitted by *Longidorus elongatus*. Neth. Jour. Plant Pathol. 71:33.

Mellor, Frances C., and R. Stace-Smith
1963. Reaction of strawberry to a ringspot virus from raspberry. Canadian Jour. Bot. 41:865–70.

Posnette, A. F.
1952. New virus diseases of *Ribes*. East Malling Research Station, Report for 1951, p. 133.
1964. Transmission studies of gooseberry vein banding virus. East Malling Research Station, Report for 1963, p. 110.

Price, W. C.
1936. Specificity of acquired immunity from tobacco ringspot disease. Phytopathology 26:665.

Reinders, E.
1957. Leerboek der algemene plantkunde [Textbook of general botany] 1:258. Amsterdam.

Richter, J., H. Kegler, and G. Zahn
1966. Isolierung des Himbeerringfleckenvirus [raspberry ringspot virus] aus roter Johannisbeere (*Ribes rubrum* L.). Phytopath. Z. 57:259.

Rietsema, I.
1955. Hybrides interspécifiques des genres *Ribes* et *Rubus*. Fourteenth International Horticultural Congress, Report for 1955, p. 712.

Schmelzer, K.
1963. Untersuchungen an Viren der Zier- und Wildgehölze. I. Mitteilung Virosen an *Viburnum* und *Ribes*. Phytopath. Z. 46:17.

Schuch, K.
1957. Viruskrankheiten und ähnliche Erscheinungen bei Obstgewächsen. Mitt. Biol. Bundanst. Land- und Forstwirtschaft 88:61.
1963. Untersuchungen über den Nachweis des Raspberry Ringspot Virus bei des roten Johannisbeere in Deutschland. Nachr. Bl. Dtsch. Pflanzenschutzdienst 7:105.

Thresh, J. M.
1964. Association between black currant reversion virus and its gall-mite vector (*Phytoptus ribis* Nal.). Nature (London) 202:1085.
1965. The effects of gall mite on the leaves and buds of black currant bushes. Plant Pathology 14:26.
1966*a*. Field experiments on the spread of black currant reversion virus and its gall-mite vector (*Phytoptus ribis* Nal.). Ann. Appl. Biol. 58:219.
1966*b*. Virus diseases of black currant. East Malling Research Station, Report for 1965, pp. 158–63.
1967. Virus diseases of red currant. East Malling Research Station, Report for 1966.

Winter, A. G.
1940. Virusartige Erkankungen der roten Johannisbeeren (*Ribes rubrum*). Z. Pflanzenkrankheiten 1:512.