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Virus diseases of berry plants in Finland

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Abstract. Virus diseases of berry plants became more common and harmful in the 1960s, when berry cultivation expanded in Finland.

Virus diseases seldom occur in strawberry because the main vector, *Chaetosiphon fragaefolii,* does not thrive in Finland. However NEPO-viruses are found in Finland in plant nurseries and in berry cultivations, and they may become a danger for strawberry as well as for raspberry growing. Both wild and cultivated raspberries are commonly infected by viruses. The vector aphids also occur in Finland. Reversion disease infects black currants. The veinbanding virus disease is common in red currants and gooseberries.

Virus diseases of berries are poorely investigated in Finland. The healthy plant propagation and certification scheme was established in the 1970s. More research is needed in order to understand our virus problems, to develop proper test methods, and to prevent virus spread.

Index words: berry plants, virus diseases

Introduction

Virus diseases of berry plants were nearly unknown in Finland until the 1970s. Only an epidemic-like occurrence and first spread over the whole country of a vector, the gall mite *(Eriophyes ribis)* had been described earlier (HUKKINEN 1923). As a result of a change in agricultural policy in the 1960s, farmers began to specialize and cultivate unconventional plants. Particularly farmers in central and eastern Finland had to find crops suitable for their small hill-side fields that would also help them avoid competition with the cereal growers in southern Finland. At the same time, the general market situation was favourable for berry cultivation because dairy industry began to use more berries and fruit in their products, e.g. yoghurts.

Strawberry cultivation area increased from 953 ha in 1973 to 2825 ha in 1983 (YEARBOOK OF FARM STATISTICS 1983). The area of black currant, the second important berry, has not increased recently, but many black currant fields were replanted in the 1970s, partly as a attempt to control mildew *(Sphaerotheca ribis)* by using a more resistant cultivar than before.

Originally berries were cultivated in small home gardens scattered all over the country, which naturally hindered outbreaks of epidemics. Thus many diseases, particularly virus diseases, remained unnoticed and unrecognized. Fungal diseases were known earlier, and their control by fungicides was adviced to farmers. The rapid increase in commercial berry growing also increased the demand for propagation material. In this situation plant nurseries failed to keep the quality of planting material high enough, and lots of ungenuine and diseased plants were produced and sold. At the beginning of the 1970s, a committee was called to plan the production of healthy and genuine propagation material of berry plants, and tests to index their virus diseases were carried out. In 1976, the healthy plant propagation programme was confirmed and settled by law, and a station to maintain and propagate healthy and genuine planting material was founded (BREMER and YLIMÄKI 1978).

Virus diseases of strawberry

54 virus diseases and 8 mycoplasma diseases are known to infect strawberry in the world (AERTS 1974). Harmful virus diseases can be divided into two groups according to their vectors: aphid-transmitted and nematode-transmitted diseases (Tables 1 and 2). Strawberry aphid, *Chaetosiphon fragaefolii* and other *Chaetosiphon* sp., transmit several viruses of strawberry, the most common in Europe being strawberry crinkle, strawberry mottle, strawberry veinbanding, and strawberry mild yellow edge. Only the first two have been described in detail (MAAS 1984). Aphid-borne virus diseases have caused severe yield losses in central and southern Europe (AERTS 1974, BABOVIC 1976). However, none of the *Chaetosiphon* aphids occurs in Finland because of the cold climate. Even in northern Germany, cold winters restrict the propagation and spread of *C. fragaefolii,* the aphids often die before the latent period of the virus is completed (KRCAL 1980). Some other aphids capable of transmitting strawberry viruses occur in Finland, but they are inefficient vectors (MAAS 1984). Thus aphid transmissible viruses spread in Finland mainly by the help of man through vegetative propagation material. Further, sources of infection also seem to be scarce. The author tested wild strawberries *(Fragaria vesca)* collected from field borders and forests, and none of them was virus infected. According to similar tests, about 12 % of the plants in strawberry fields were virus infected before tested healthy plants were used (BREMER and PETHMAN 1978). Part of the planting material was

Table 1. Strawberry virus diseases.

Disease	Cryptogram	Virus group	Transmission by Vector	Sap	Distribution	In Finland
1) Strawberry mottle	- - -	- - -	Chaetosiphon sp.p.	+?	World wide	+
2) Strawberry crinkle	*/*;*/*:u/E:S,1/Ap	Rhabdovirus	»	—	In Europe, USA	+
3) Strawberry veinbanding	*/*;*/*:S/S:S/Ve/Ap	Caulimovirus	» + Amphomorpha and Myzus sp.p.	+	»	+?
Strawberry mild yellow edge	- - -	Luteovirus	Chaetosiphon sp.p.	—	World wide	+?

1) Sylvester et al. (1976)
2) Frazier & Converse (1980)
3) Maas (1984)

Table 2. NEPO-viruses in berry plants.

Virus	Cryptogram	Host	Vector	Other means		Distribution of the vector the virus in Finland	
Arabis mosaic virus	R/I:*/41:S/S:S/Ne	Strawberry, raspberry, currants	Xiphihema diversicaudatum, X. index	Sap, seed pollen	In Europe	—	+
Raspberry ring spot	R/1:(2,4/43)+ (1,4/30) OR 2×1,4/(46:S) S/S:S/C,Ve/Ne	Strawberry, raspberry, currants	Longidorus elongatus, L. macrosoma	Sap, seed pollen	»	+ +	—
Tomato black ring	R/*:*/38:S/S:S/Ne R/I:2,5+1,5	Strawberry, currants	L. elongatus L. attenuatus	Sap, seed, pollen	»	+ ?	+
Strawberry latent ring spot	R/1:2,6 2×1,6/38:S/S:S/Ne	Strawberry, black & red currant, raspberry	X. diversi-caudatum X. coxi	Sap, seed, pollen	»	— —	+
Tobacco ring spot	R/1:2,2/40: S/S:S/Ne	Strawberry, raspberry, currants	X. americanum	Sap, seed	USA, some European countries	—	—
Tomato ring spot	R/1:2,3/40: S/S:S/Ne	Raspberry	X. americanum	Sap, seed	USA, in imported plants in Europe	—	—

imported. It seems that aphid transmissible virus diseases spread to Finland only in imported planting material, and the use of tested plants controls them effectively.

NEPO-virus diseases

NEPO-viruses, Arabis mosaic, raspberry romg spot, tomato black ring, and strawberry latent ring spot, cause severe damage to strawberries in many countries, the first three being most destructive (Table 3). All these viruses have been found in Finland in plant nurseries and in the field (TAPIO 1972, 1985, BREMER 1985), but it is not known how common they are or whether they are a potential danger to strawberry cultivation in Finland. NEPO-viruses also infect raspberry and currants, and they are especially harmful to raspberry.

All NEPO-viruses have similar properties, but they are distinctly different viruses. They contain bipartite single-strand RNA genomes, which are encapsidated separately but have identical protein coats (HARRISON and MURANT 1977). Both parts are necessary for infection. NEPO-viruses are transmitted by nematodes *Xiphinema* and *Longidorus* sp. via sap, seed, and pollen (HARRISON and MURANT 1977). *Xiphinema* nematodes have not been found in Finland, though Arabis mosaic and strawberry latent ring spot viruses, which are transmitted by them (TAYLOR and THOMAS 1968), occur in Finnish plant nurseries (TAPIO 1972, 1985). They have probably been imported to Finland in foreign propagation material. The only means they can spread here in nature is via seed or pollen. Arabis mosaic is transmitted via seed of several weeds, strawberry, and raspberry. Pollen transmission by weeds and strawberry is also known (LISTER and MURANT 1967).

Berry plants are not propagated by seed except in breeding. Thus seed transmission of the viruses that have no vector in Finland, is not important. Pollen transmission, if it causes infection in the mother plant, can be very destructive in the production of virus tested plants. In one experiment, healthy

strawberry mother plants were pollinated by pollen containing raspberry ring spot virus, but no plants became infected. Infected pollen competed poorly with virus-free pollen (LISTER and MURANT 1967). However, raspberry bushy dwarf virus is naturally transmitted via pollen, and plants get infected (MURANT et al. 1974).

At present several tested strawberry cultivars are available in Finland. On average, they have yielded 59 % more than untested plants in experimental fields (KALLIO et al. 1980). At the same time yields in farmers' fields have increased, on average 1000 kg/ha (ASSOCIATION OF BERRY GROWERS, oral comm.). However, most of this increase may be due to the eradication of mites and leaf nematodes.

Virus diseases of raspberry

Red raspberry *(Rubus idaeus)* is not largely grown in Finland, and its area has decreased from about 168 ha in 1973 to 92 ha in 1983 (YEARBOOK OF FARM STATISTICS 1983). Black raspberry *(R. occidentalis)* is only grown in home gardens. Recently, however, raspberry cultivation has aroused more interest, and some fields have been planted. Experiments on suitable cultivation and harvesting methods, including the control of pests and cane diseases, are in progress.

Wild raspberries are common in Finland. They often show symptoms of virus diseases (JAMALAINEN 1957) as well as virus-like yellow fleck symptoms caused by the mite *Eriophyes gracilis* (LINDROTH (LIRO) 1902). According to TAPIO (1961), several virus diseases occur in Finland, e.g. red raspberry mosaic, raspberry vein chlorosis, raspberry vein banding, raspberry yellows, raspberry leaf mottle, and raspberry leaf curl, but they have not been described in more detail. A mycoplasma disease, *Rubus* stunt, has also been found in Finland.

More than twenty viruses infecting raspberry have been found in Europe, but not all of them are significant, and some are still poorly described. Some virus diseases transmitted by aphids or nematodes have caused severe yield losses (FREEMAN and STACE-SMITH 1970, BAUMANN 1984, 1986). Raspberry viruses often occur together in the same plant. Thus

Table 3. Virus diseases of raspberry (Rubus idaeus) occurring in Europe.

Disease and virus	Cryptogram	Virus group	Distribution	Vector	Transmission by sap	seed	pollen
1) Raspberry bushy dwarf	R/1:(2.0+0.8+0.3) /(24):S/S:S/O	Possible ilar virus	In some cvs. world wide	---	+ +	+	+
Heat labile viruses:							
Raspberry leaf mottle	Not enough characterised	?	Common in Europe	Amphoropha rubi	—	—	—
Raspberry leaf spot	»	?	»	»	—	—	—
Black raspberry necrosis	»	?	»	»	+	—	—
Heat stabile viruses:							
2) Raspberry vein chlorosis	*/:*/*:Ue/E:S /Ve/As	Rhabdovirus	» + in USA, Canada	Aphis idaei	—	—	—
3) Rubus yellow net	*/*:*/*:U/*:S /Ve/Ap	A possible cacao swollen shoot virus	»	Amphoropha rubi	—	—	—

1) Murant 1976
2) Jones et al. 1977
3) R. Stace-Smith & Jones 1978

raspberry mosaic is caused by several viruses (Table 3), and symptoms vary according to the combination of infecting viruses.

The testing and production of virus-free raspberries by heat treatment was started in the early 1960s on the initiative of TAPIO. Virus tested raspberries have performed well. For example, the yield of cultivar Preussen in a field experiment was 8000—6000 kg/ha during five years compared to 530—1200 kg/ha of untested, normal plants of the same age (BREMER 1980). At present virus tested planting material of three cultivars is available.

Virus diseases of currants and gooseberries

Several virus diseases of currants have been found in Finland (Table 4) but none of them is well characterized, and they have been identified mainly on the basis of their symptoms in host and test plants.

The reversion disease, the causal agent of which is unknown, can be very harmful to black currants, and several strains are known. The severe strain, which causes deformations and sterility of flowers, is rare in Finland. The weaker strains have also become rare after virus tested plants became commonly used.

The veinbanding virus disease and its aphid vectors are very common in red currant and gooseberry. Infectious variegation and some viruslike diseases have been found in some currant fields (BREMER 1983).

Same NEPO-viruses infect both currants and strawberry. In Finland, raspberry ring spot and tomato black ring are found in black currants (BREMER 1983). They do not seem to be harmful to the plants but may be spread and preserved with them.

Other berries

Nordic bramble, *Rubus arcticus,* and its hybrids with *R. stellatus* are grown on a small scale for berry industry. A sap transmissible, unidentified virus causing yellow mosaic on the leaves of Nordic brambles has been found (BREMER 1985).

Aronia melanocarpa cv. Viking is cultivated for berry production. A virus, causing ring spot symptoms on the leaves and having isometric particles, has been found. The disease does not seem to spread (BREMER 1984).

A mycoplasma disease causing withces' broom symptoms occurs in blueberries *(Vaccinium myrtillus)* and red bilberries *(V. vitis-idaea)* in forests, and it has probably been in Finland for a long time (BREMER 1981).

Table 4. Virus diseases of currants and gooseberry.

Disease	Causal agent	Vector	Sap transmission	Distribution abroad and in Finland	Importance
Reversion of black currant	Unknown	Mite, Eriophyes ribis	—	Common	+ + +
Veinbanding of gooseberry	Probably virus	Several aphid sp.p.	—	»	+ +
Veinbanding of red currant	»	»	—	»	+ +
Infectious variegation of currants	»	Unknown	—	Rare	—
Cucumber mosaic virus	R/1:1/18:S /S:S/Ap	Aphids	+	Seldom in Ribes, common in other plants	—

Discussion

Virus diseases of berry plants are not a serious problem in Finland, mainly because the cold climate restricts vectors, and there are probably not many virus sources.

Wild strawberries seem to be free of viruses, and about 90 % of commercial strawberry farmers now use tested healthy plants for founding their fields.

In contrast to strawberry, wild raspberries and raspberries in home gardens are often virus-infected. Aphid vectors *Aphis idaei* and *Amphorophora rubi,* which transmit several viruses, are common in Finland (HEIKINHEIMO 1956).

Reversion disease occurs in black currants and occasionally in wild *Ribes alpinum*. The vector, *E. ribis,* occurs all over Finland, though to a lesser extent in the north. The use of tested planting material has diminished the occurrence of the vector and disease.

NEPO-viruses occur in berry plants and in plant nurseries, where they are harmful to many perennial ornamental plants. NEPO- and other soil-borne viruses might become a problem in the future because they persist in soil and infect nursery plants. Thus there is a consistent danger of their spreading into new areas.

More research should be done on soil-borne viruses, on collecting and comparing isolates and characterizing them. To get quick and reliable test methods, suitable immunological tests and practical applications of nucleic acid analysis and DNA hybridization for large scale tests should be developed. Further, because of our short summer, there is an increasing interest amont nurseries in propagating plants through tissue culture. The first commercial laboratory already exists. New cultivars are propagated through tissue culture and should also be tested. Tissue culture propagation is a very effective way of spreading plant diseases if careful inspection and testing are neglected.

Another subject worth while examining would be virus and virus-like diseases of currants and gooseberry. They are as a whole poorly investigated. The etiology of the reversion disease is not known. A potyvirus, a bacterium (JACOB 1976), and a mycoplasma (SILVERE 1970) have been suggested as causes of this disease. The agent of the veinbanding disease of red currant and gooseberry is also unknown, though the disease causes yield losses (THRESH 1970).

A good knowledge of our viruses is necessary for developing proper test methods and for preventing virus spread into fields. It is vitally important for resistance breeding, too. Resistance against some viruses has been found in red raspberry. Inserting viral DNA copies into plants has opened new possibilities for getting virus tolerant and resistant plants. (HARRISON et al. 1987). The necessity of a quarantine station (jointed into an existing plant protection institute) for nontested perennial plants, such as bushes and trees, should be taken into consideration. Plant quarantine inspection should include plant nurseries and new cultivars of perennial plants bred in Finland.

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Suomessa esiintyvät marjakasvien virustaudit

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Marjan viljelyn laajetessa kahtena viime vuosikymmenenä lisääntyi myös taimien kysyntä. Tällöin markkinoille pääsi myös heikkolaatuista aineistoa ja marjakasvien tautisuus lisääntyi. Virustaudit osoittautuivat hankalimmiksi, koska viljelijällä ei ole mahdollisuuksia niiden torjumiseksi. Tervetaimitoiminnan alettua 1970-luvulla tilanne on parantunut.

Mansikan virustauteja on meillä tutkittu vain vähän. Testaamattomilla taimilla perustetuilla mansikkaviljelmillä noin 12 % kasveista oli viroottisia. Virustaudit mansikassa lienevät tuontitavaraa, sillä pahimmat saastunnat on todettu ulkomailta tuoduissa kasveissa. Lisäksi mansikan virustautien pahimmat levittäjät, Chaetosiphon-suvun kirvat eivät menesty kylmässä ilmastossamme.

Meillä on tavattu taimistoissa monissa kasvilajeissa useita ankeroislevintäisiä, ns. NEPO-viruksia, jotka ovat haitallisia myös mansikalle. Meillä ei ole tietoa niiden esiintymisestä mansikalla.

Vadelman virustautitutkimus on myös rajoittunut virustautitestauksiin ja terveiden taimien tuottamiseen. Kuitenkin on todettu, että virustaudit ovat yleisiä sekä viljellyissä että luonnonvaraisissa vadelmissa ja niiden levittäjät iso- *(Aphis idaei)* ja pieni vattukirva *(Amphorophora rubi)* esiintyvät yleisinä meillä. Vadelmalle ovat haitallisia myös monet NEPO-virukset. Niiden yleisyyttä vadelmissa ei tunneta.

Virustaudeista puhdistaminen on kannattanut, sillä terveet vadelmat ovat tuottaneet moninkertaisen sadon testaamattomiin taimiin verrattuina usean vuoden ajan.

Herukoissa on meillä todettu useita virustauteja. Kaikki eivät ole haitallisia. Satoa antavat reversion- eli suonenkatotauti mustaherukalla ja suonikloroosi punaherukalla ja karviaisella. Suonenkatotaudin aiheuttajaa ei tunneta. Tauti leviää äkämäpunkkien *(Cecidophyopsis (Eriophyes) ribis)* välityksellä. Tämä äkämäpunkkilaji esiintyy meillä yleisenä.

Suonikloroosi leviää useiden kirvalajien välityksellä. Nämä kirvalajit ovat meillä yleisiä punaherukassa.

NEPO-viruksia on tavattu meillä sekä musta- että punaherukassa, mutta ne eivät ole olleet haitallisia. Kuitenkin ne saattavat levitä herukoiden mukana uusille viljelyksille.

Marjakasvien virustaudit, etenkin herukan ja mansikan, mutta myös vadelman ovat meillä samoinkuin muuallakin liian vähän tutkittuja. Monien ns. virustautien aiheuttajaa ei tunneta, eräiden leviämistapaa ei tunneta ja kaikille tarvittaisiin tehokkaat testausmenetelmät. Alkanut tervetaimitoiminta tarvitsee sopivia testausmenetelmiä sekä perustietoa taudinaiheuttajista, jonka avulla tautien levinnän rajoittaminen voidaan toteuttaa. Meillä olisi syytä kiinnittää erityisesti huomiota maalevintäisten etenkin NEPO-virusten rotulajiston selvittelyyn tehokkaiden testausmenetelmien saamiseksi.