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Survey of viruses and mycoplasmas in strawberry

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Abstract

The present survey based on the literature lists the viruses and mycoplasmas infecting strawberries and endeavours to sort out their relationships and synonyms. Remarks and suggestions of several specialists from various countries were taken into consideration. The data have been assembled in tables. In total, 54 different viruses have been reported to infect strawberry and eight diseases have been attributed to mycoplasmas.

Introduction

'Strawberry yellows' described in America is the oldest known virus disease of strawberry. Plakidas (1927) already proved that this disease is caused by a virus. The rapidly increasing interest in research on viruses and virus diseases in strawberries led to many publications, and in Anderson's (1969) 'Strawberry world bibliography 1920–1966' over 495 publications are recorded.

However, with the increasing number of virus diseases the identification of the causative viruses became an increasing problem. Plakidas (1964) properly stated: 'The virus situation in strawberries is exceedingly complicated and more than a little confusing', and this still holds. There is a great need for a survey of viruses described so far in strawberry. The description and/or comparison of the pertinent viruses has almost exclusively been done on the basis of their variable biological properties. Furthermore, an increasing number of diseases, until recently ascribed to viruses, is now thought to be caused by mycoplasmas. As mycoplasmas behave as viruses from an epidemiological point of view, they have been included in the present list.

The publications of Frazier (1970), Frazier and Posnette (1958), Maassen (1964), Mellor and Fitzpatrick (1961) and of Plakidas (1964) give ample information on the various viruses and virus diseases in strawberry and give a good idea of the state of knowledge at the time of publication. Although these publications are not complete, they still are of great value and were used as a basis for the present compilation.

Problems arising when listing the viruses of strawberry

It is much more difficult to compare the strawberry viruses discribed in various countries and to judge their synonyms, than to do so with the viruses of most other herbaceous plants. There are a number of reasons.

Many strawberry viruses are not transmissible mechanically, even several of those

which are transmitted by insects in the non-persistent way, a.o. to other herbaceous testplants and to be studied for their so called intrinsic properties and for their host ranges. This usually is ascribed to the tannins or tannic acids in strawberry plants, precipetating protein and virus when plants are ground or extracted (Bawden and Kleczkowsky, 1945). However, Nepo viruses naturally infecting strawberries can be easily isolated from strawberry plants, suggesting that the nature of the viruses concerned plays a role as well. Anyhow, for virus transmission and host range studies we mainly have to rely on vector and graft transmission techniques.

Virus diseases in strawberry are often due to complex infections. For example, Plakidas (1964) mentions 14 different viruses, which can participate in the yellow edge-severe crinkle complex. Furthermore, different strains have been found of these viruses; for example Frazier (1960 a and 1960 b) distinguished 19 different variants of the 'mottle' virus and 4 strains of the 'vein banding' virus. The most important characters to identify the viruses of strawberry are the symptoms caused in the indicator plants and the vector-virus-plant relations. These biological properties are very variable and depend on the plant from which the virus has been taken, the indicator plant in which the virus is being studied, the vector species and the method of transmission.

These factors themselves are variable and depend on many external conditions, such as light, temperature and nutrition. Detection of small differences in symptoms and vector specificity have led to a continuous splitting of viruses and description of new viruses. Thus, the identity of most viruses in strawberry, viz. those only known by their biological properties, is not well established. Through refined techniques, the intrinsic properties of viruses in strawberries may become known in the future, making virus identification more reliable. However, viruses will remain greatly variable (Bos, 1970). Although the number of viruses may decrease through further careful study, new forms of certain viruses will be distinguished by further differentiation in host range or cultivar reaction. Moreover, because of an intensive, often international trade the viruses are intensively and widely spread. It also becomes more and more apparent that viruses have a much wider host range than was thought for long.

Survey

Decisions concerning identity or non-identity of strawberry viruses often are arbitrary. In order to make this survey international in scope, the manuscript was sent to several foreign researchers working on strawberry viruses or on virus identification and virus nomenclature.

To make the list concise and easily accessible it has been presented in tabular form. Because of the general usage of English in plant virology, English common names were used. Synonyms and data on their relationships have been added.

Samenvatting

Overzicht van virussen en mycoplasma's bij aardbeien

Het aantal virussen waarvan bekend is dat zij bij aardbeien kunnen voorkomen is vrij groot. Daar de beschrijving van de specifieke aardbeivirussen uitsluitend gebeurt

op basis van de zgn. biologische eigenschappen is de identificatie en de vergelijking van deze virussen vaak een probleem. Een samenvattend overzicht van de verschillende virussen, die bij aardbeien tot nu toe gevonden werden, alsook van hun synoniemen en verwantschappen, bleek gewenst.

Van een stijgend aantal ziekten, waarvan men tot voor kort meende dat zij door virussen werden veroorzaakt, wordt thans aangenomen dat zij het gevolg zijn van mycoplasma's. Daar mycoplasma's zich epidemiologisch ook als virussen gedragen werden zij in dit overzicht eveneens opgenomen.

Teneinde tot een zo betrouwbaar mogelijke internationale inventarisatie te komen werd het manuscript van deze publikatie aan verschillende buitenlandse onderzoekers, die op het gebied van de aardbeivirussen werkzaam zijn, gezonden. Van hun opmerkingen en suggesties werd dankbaar gebruik gemaakt bij de samenstelling van dit overzicht.

Het overzicht werd in tabelvorm opgesteld en omvat de volgende rubrieken: (1) virussen van het 'geelrand-krinkel' complex, (2) andere aardbeivirussen, (3) virussen met een brede waardplantenreeks (waaronder aardbeien), (4) virussen van andere waardplanten geïsoleerd uit aardbeien (vermoedelijk toevallige infecties), (5) virussen van andere waardplanten welke kunstmatig op aardbeien konden overgebracht worden, en (6) ziekten die vroeger toegeschreven werden aan virussen, doch die vermoedelijk veroorzaakt worden door mycoplasma's.

In totaal worden in de tabellen 54 verschillende virussen vermeld, terwijl 8 ziekten worden opgenomen waarvan bewezen is of waarvan verondersteld wordt dat zij mycoplasma's als oorzaak hebben.

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Table 1. Viruses of the strawberry 'yellows-crinkle' complex.

Virus	Author	Year	Synonyms	Author	Year
I. Strawberry mottle viruses					
1. strawberry mottle virus	Prentice	1952	1. non-persistent component of severe crinkle	Wood and Whitehead	1947
			2. mottle	Thomas	1949
			3. non-persistent component of yellows	Mellor and Fitzpatrick	1951
			4. non-persistent isolates	Schöniger and Bauer	1955
				Schöniger	1956
				Domes	1957
				Krczal	1959
				Maassen	1959
				Borchardt	1960
			related with:		
			5. mild crinkle (= mottle + latent A after Frazier, 1970)	Harris	1938
				Harris and King	1940
				Prentice and Harris	1942
					1946
			6. virus 1 (= mottle + latent A after Frazier, 1970)	Prentice	1948
			7. type 1 (= mottle + latent A or latent C after McGrew, 1956)	Demaree and Marcus	1951
2. strawberry curly dwarf mottle virus	Frazier and Posnette	1958			
3. strawberry rusty leaf mottle virus	Frazier and Posnette	1958			
II. Strawberry vein banding viruses					
4. strawberry leaf curl virus	Prentice	1952	*related with:* Virus 5 (= leaf curl virus + latent A after Frazier, 1970)	Prentice	1952
5. strawberry vein banding virus	Frazier	1955b	vein banding virus	King and Stingl	1963
6. strawberry yellow vein banding virus	Frazier and Posnette	1958			
7. strawberry necrosis virus	Schöniger	1958			
8. strawberry chiloensis vein banding virus	Frazier	1960			
9. strawberry eastern vein banding virus	Frazier	1960			

Table 1. (continued)

Virus	Author	Year	Synonyms	Author	Year
III. Strawberry crinkle viruses					
10. strawberry crinkle virus	Prentice	1949	1. strawberry virus 4	Johnson	1927
			2. crinkle	Zeller and Vaughan	1932
			3. *Fragaria* virus 2	Zeller and Vaughan	1932
			4. *Marmor fragariae*	Holmes	1939
			5. persistent component of severe crinkle	Wood and Whitehead	1947
			related with:		
			6. virus 3 (= crinkle virus + latent A after Frazier, 1970)	Prentice	1949
11. strawberry vein chlorosis virus	Prentice	1952	*related with:* virus 4 (= vein chlorosis virus + latent A after Frazier, 1970)	Prentice	1952
12. strawberry latent A virus	Frazier	1953	1. strawberry latent strain A	Frazier	1953
			2. strawberry latent A virus (mild form)	Rorie	1957
13. strawberry latent B virus	Frazier	1953			
14. strawberry lesion A virus	Frazier and Posnette	1958			
15. strawberry lesion B virus	Frazier and Posnette	1958			
16. strawberry chlorotic spot virus	Maassen	1966			
17. strawberry epinasty virus	Maassen	1968			
IV. Strawberry mild yellow edge virus					
18. strawberry mild yellow edge virus	Prentice	1948	1. persistent component of yellows	Mellor and Fitzpatrick	1951
			related with:		
			2. yellow edge	Harris	1933
				Massee	1935
				Harris and King	1940
					1942
			3. virus 2 (= strawberry mild yellow edge virus + latent A after Frazier, 1970)	Prentice	1948

Tabel 1. Virussen van het 'geelrand-krinkel-complex.

Table 2. Other special strawberry viruses.

Virus	Author	Year	Synonyms	Author	Year
1. strawberry stunt virus	Zeller and Weaver	1941	1. *Fragaria* virus 5	Zeller and Weaver	1941
			2. *Nanus cupuliformans*	Zeller and Weaver	1941
2. strawberry leafroll virus	Berkeley and Plakidas	1942	*after Smith (1957) but no exact:* strawberry leaf curl virus	Prentice	1952
3. strawberry latent C virus	McGrew	1956	*related with:* type 2 (= latent A + latent C after McGrew, 1956)	Demaree and Marcus	1951
4. strawberry necrosis virus	Maassen	1961			
5. strawberry band mosaic virus	Maassen and Nemeth	1961			
6. strawberry chlorotic fleck virus	Horn and Carver	1962			
7. strawberry lethal decline virus	Schwartze and Frazier	1964	*possible after Frazier and Jensen (1970):* peach X-disease	(see also table 6.2)	
8. strawberry pseudo mild yellow edge virus	Frazier	1966			
9. strawberry vein necrosis virus	Maassen	1968			
10. strawberry pallidosis virus	Frazier and Stubbs	1969			
11. strawberry feather leaf virus	McGrew	1970			

Tabel 2. Andere specifieke aardbeivirussen.

Table 3. Viruses with a wide host range (including strawberries); Nepo viruses.

Virus	Authors described the virus on strawberries	Year	Synonyms	Author	Year
1. arabis mosaic virus	Harrison Lister	1958 1958a	1. strawberry mosaic virus	Posnette	1956
			2. raspberry yellow dwarf virus	Harrison	1958
			3. strawberry yellow crinkle	Harrison	1958
2. raspberry ringspot virus	Lister	1958a	1. red currant ringspot virus (probably) see also	Klesser Harrison	1951 1961
			2. scottish raspberry leaf curl virus	Cadman	1956
3. tomato black ring virus	Lister	1958b	1. potato bouquet virus	Köhler	1952
			2. beet ringspot virus	Harrison	1957
			3. lettuce ringspot virus	Smith and Short	1959
			4. potato pseudo aucuba virus	Bercks	1962
4. tomato ringspot virus	Frazier et al.	1961	1. yellow bud virus	Frazier et al.	1961
			2. peach yellow bud mosaic virus	Cadman and Lister	1961
			3. grapevine yellow vein virus	Gooding et al.	1967
5. strawberry latent ringspot virus	Lister Lister	1963 1964			
6. new (?) Nepo virus I	Lister	1970	1. strawberry vein necrosis virus	Stingl and King	1965
			2. strawberry vein pattern virus	Stingl	1965
7. new (?) Nepo virus II	Lister	1970	tumor virus	Goidanich et al. Canova and Tacconi	1964 1965
8. tobacco streak virus	Stace-Smith and Frazier	1971	strawberry necrotic shock virus	Jorgensen Frazier et al.	1957 1962

Tabel 3. Virussen met een brede waardplantenreeks (aardbeien inbegrepen); Nepo-virussen.

Table 4. Viruses of other hosts isolated from strawberries (probably incidental contaminants).

Virus	Author	Year	Synonyms	Author	Year
1. tobacco necrosis virus	Fulton, J. P. Frazier	1952 1955a	*related with:* virus described by	Faccioli	1969
2. tobacco mosaic virus	Cornuet and Morand	1960			

Tabel 4. Virussen van andere waardplanten geïsoleerd uit aardbeiplanten (vermoedelijk toevallige infecties).

Table 5. Viruses of other hosts found to be transmissible to strawberries (not recorded to occur naturally).

Virus	Author	Year	Synonyms	Author	Year
1. rose mosaic virus	Fulton, R. W.	1952			
2. mottle mosaic virus of red raspberry	Vaughan and Wiedman	1955	*after Vaughan and Wiedman (1955):*		
			1. raspberry yellow blotch curl virus	Chamberlain	1934
			2. raspberry decline virus	Zeller and Braun	1943
			3. raspberry yellow blotch virus	Cadman and Harris	1952
3. raspberry yellow net virus	Stace-Smith and Mellor	1957			
4. apple mosaic virus	Nyland and Engelbrecht	1958			
5. apricot ring-pox virus	Nyland and Engelbrecht	1958			
6. peach line-pattern virus	Nyland and Engelbrecht	1958			
7. sweet cherry rugose mosaic virus	Nyland and Engelbrecht	1958			
8. sour cherry yellows virus	Nyland and Engelbrecht	1958			
9. cherry leaf roll virus	Cropley	1961			
10. raspberry vein chlorosis virus	Stace-Smith	1961	raspberry chlorotic net virus	Jordović	1963
11. raspberry leaf curl virus	Stace-Smith	1962			
12. mild streak virus of black raspberry	Braun and Keplinger	1962			
13. green mosaic virus of black raspberry	Braun and Keplinger	1962			
14. raspberry line pattern virus	Basak	1968			
15. raspberry bushy dwarf virus	Barnett and Murant	1970	*related with:* apple chlorotic leaf-spot virus	Cadman	1970

Tabel 5. Virussen van andere waardplanten, die kunstmatig op aardbeien konden worden overgebracht.

Table 6. Diseases previously attributed to viruses but presumably due to mycoplasmas.

Disease	Author	Year	Synonyms	Author	Year
1. witches' broom	Zeller	1927	*after Mellor and Fitzpatrick (1961):*		
			1. strawberry virus 2	Johnson	1927
			2. *Fragaria* virus 3	Zeller	1927
			3. *Nanus fragariae*	Holmes	1939
			4. *Blastogenus fragariae*	McKinney (cited by Mellor and Fitzpatrick, 1961)	
2. peach X-disease(1)	Slack	1952	1. western X-disease	Frazier and Jensen	1970
			2. peach yellow leaf roll	Frazier and Jensen	1970
			3. X-disease of choke cherry	Braun and Keplinger	1962
			possible after Frazier and Jensen (1970):		
			4. strawberry lethal decline disease	Schwartze and Frazier (see also table 2.7)	1964
3. Aster yellows (A)	Frazier and Thomas	1953	*after Mellor and Fitzpatrick (1961):*		
			1. western aster yellows virus		
			2. *Callistephus* virus 1 A	Smith	1937
			3. *Chlorogenus callistephi* var. *californicus*	Holmes	1939
			after Frazier (1970) and Plakidas (1964):		
			4. chlorotic phyllody	Plakidas	1951
4. green petal (B,C)	Posnette	1953	clover phyllody (B)	Frazier and Posnette	1957
5. bronze leaf wilt	Frazier and Posnette	1957	1. clover witches' broom	Frazier and Posnette	1957
			possible:		
			2. *Delphinium* yellows (2)	Posnette and Ellenberger	1963
6. multiplier disease	Sehgal	1961			
	Sehgal and Boone	1964			
7. big bud (3)	Helms	1962			
8. Rubus stunt (D) (4)	van der Meer and de Fluiter	1970	raspberry witches' broom		

Evidence for mycoplasma: (A) Kacharmazov (1972); (B) Cousin et al. (1970); (C) Beakbane et al. (1971); (D) Murant and Roberts (1971). Only experimentally transmitted to strawberry by: (1) Slack (1952); (2) Posnette and Ellenberger (1963); (3) Helms (1962); (4) Van der Meer and De Fluiter (1970).

Tabel 6. Ziekten vroeger toegeschreven aan virussen, doch vermoedelijk veroorzaakt door mycoplasma's.

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