

***Amaranthus* Species (Family: Amaranthaceae) as Hosts of Plant Viruses: A Review**

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The *Amaranthus* species as test plants, perennial virus hosts and inhibitor-containing plants are equally important in virus research. Of the about 1000 species of the genus *Amaranthus* 63 species (including four synonymous species) have so far been found to be susceptible to viruses according to our knowledge. The *Amaranthus* species are known to be susceptible to 121 viruses, and some 470 host-virus relations have been detected among them. There are remarkable differences in virus susceptibility between the *Amaranthus* species; some species, e.g. *Amaranthus caudatus* (syn.: *A. cruentus*) are susceptible to some 84 viruses while others (e.g. *Amaranthus aurora*, *A. blitoides* etc.) only to one each. Out of the viruses cucumber mosaic virus has the largest number of *Amaranthus* hosts (42 species), while e.g. *Arracacha* virus A and carnation Italian ringspot virus each has but a single *Amaranthus* host.

Out of the 63 *Amaranthus* species susceptible to 121 viruses belonging to 24 virus groups (and to one "unidentified" and one "complex or mixed" virus group) the largest number of susceptible *Amaranthus* plants are known in the potyvirus group.

Economic and virological importance of the *Amaranthus* species

Among the more than 1000 annual, perennial, herbaceous, woody or shrub species of some 60 genera in the family Amaranthaceae occurring all over the world through mostly in subtropical and tropical regions many play a highly important role in plant virology.

From the *Amaranthus* genus which includes some 100 species only *Amaranthus graecizans* (syn.: *A. angustifolius*) var. *sylvestris* and *A. lividus* ssp. (var.) *ascendens* are indigenous in Europe (Solymosi and Priszter, 1984). Aellen (1959, 1961) the monographer of name listed about 50 species in Europe – including a large number of hybrids (cf. Priszter, 1985) – introduced from America in the last two centuries. Particularly noteworthy are the ornamentals known as the oldest cultivated plants on the Earth (*Amaranthus caudatus*, *A. cruentus*) – produced as grain crops for the protein, starch and oil content of their seeds and used for human nutrition too –, and the leaf vegetable *Amaranthus tricolor* grown in South-China and India. None the less is wide-spread *Amaranthus viridis* important; it is not a mere weed plant but also a green vegetable locally known as "Cholai" in several parts of Delhi and adjacent areas in India. These plants together with other species play a very important role in plant virology (Hollings, 1965; Edwardson, 1974a,b; Horváth, 1975, 1976a,b, 1983a,b, 1985, 1991a,b; Edwardson and Christie, 1986a,b,c).

The importance of the *Amaranthus* species lies, on the one hand, in their role as test plants in detecting certain viruses. On the other hand, as natural host plants they have a part in the survival and circulation in nature of certain viruses (reviewed by Horváth, 1991a). Among them the perennial *Amaranthus deflexus* and *A. deflexus* var.

rufescens are particularly important (see Lovisolo and Lisa, 1976, 1979; Horváth, 1983b). According to Schmelzer and Molnár (1975) in Hungary *Amaranthus retroflexus* is a highly important reservoir for cucumber mosaic virus. The strong affinity between *Amaranthus* species and viruses – as pointed out earlier (reviewed by Horváth, 1983a,b, 1985, 1991a,b) – is confirmed by the fact that 12 *Amaranthus* species are known as natural virus hosts: *A. albus*, *A. caudatus*, *A. deflexus*, *A. gracilis*, *A. hybridus*, *A. lividus*, *A. palmeri*, *A. paniculatus*, *A. quitensis*, *A. retroflexus*, *A. spinosus* and *A. viridis* (Horváth, 1991a). The list is not complete, since in several known natural host-virus relations the species of the plant and/or the virus have not been identified (see Phatak, 1965; Rubio-Huertos and Vela-Cornejo, 1966; Govindaswamy et al., 1967; Gracia and Feldman, 1972 etc.).

In addition to the above the *Amaranthus* species are important model plants in the virus inhibitor research (Hollings, 1966; Smookler, 1971; Ragetli and Weintraub, 1974; Noronha et al., 1980; Choi and Jung, 1984). Considerable inhibitory effect is exercised by the tissue sap of *Amaranthus caudatus* on infection by tobacco mosaic virus, tobacco necrosis virus and alfalfa mosaic virus, and by the tissue sap of *A. deflexus* and *A. mangostanus* on tobacco mosaic virus infection. This fact often has a deceptive effect on the results of the virus transmission and back-inoculation methods used in classical plant virology. This might be the reason why the literary data are not free from contradictions (cf. Horváth, 1991a).

Virus susceptibility of *Amaranthus* species

Considering that as far as we know comprehensive work has not been published on relations between *Amaranthus* species and viruses, we try to fill in the gaps with the present paper (Table 1).

In the table 63 *Amaranthus* plants are listed. Four of them (*angustifolius* = *graecizans*, *ascendens* = *blitum*, *caudatus* = *cruentus*, *gangeticus* = *tricolor*) can be regarded as synonyms. *Amaranthus sylvestris* has the synonym *A. graecizans* var. *sylvestris*, but under this name no virus susceptible plant can be found in the literature. Eight of the 121 viruses (e.g. *Amaranthus* mottle virus, *Amaranthus* mosaic virus, *Tropaeolum* mosaic virus etc.) are not exactly identified, five of them are known as strains of authentic viruses contained in Table 1 (e.g. *Physalis* shoestring mosaic virus is a strain of tobacco mosaic virus, cabbage black ring virus is a strain of turnip mosaic virus), while one virus (red current ringspot virus) is a synonym of raspberry ringspot virus in Table 1. Between the *Amaranthus* species and viruses listed some 470 host-virus relations are known (see Table 1). The *Amaranthus* species differ in virus susceptibility. *Amaranthus cadatus* (syn.: *A. cruentus*) is susceptible to 84 viruses while *A. aspera*, *A. aurora*, *A. blitoides* etc. are – to our best knowledge – susceptible to a single virus each (see Table 2). Species important from the point of view of virus epidemiology and virus ecology are: *Amaranthus retroflexus* with its susceptibility to 40 viruses, and *A. deflexus* and *A. deflexus* var. *rufescens* susceptible to 7 viruses, among them such important ones as cucumber mosaic virus and beet yellow virus. *Amaranthus bouchonii*, a species recently showing wide geographical distribution is susceptible to some 15 viruses (see Tables 1 and 2).

Table 1

Susceptible *Amaranthus* species to plant viruses

<i>Amaranthus</i> species	Viruses*	Literature
<i>Amaranthus</i> ssp.	<i>Amaranthus</i> mottle virus ¹ Ivy vein clearing virus <i>Physalis</i> shoestring mosaic virus ⁶ Tobacco streak virus	Qureshi and Mahmood (1980) Castellano and Rana (1981) Verma and Chowdhury (1984) Costa and Carvalho (1961)
<i>A. albus</i>	Tomato spotted wilt virus Alfalfa mosaic virus Beet mosaic virus Beet yellows virus Broad bean wilt virus Strawberry latent ringspot virus	Anonymous (1988) Kaiser and Hannan (1983) Schmelzer and Wolf (1977) Thornberry (1966) Schmelzer and Wolf (1977) Schmelzer and Wolf (1977)
<i>A. albus</i> var. <i>roseus</i>	Beet mosaic virus	Schmelzer and Wolf (1977)
<i>A. angustifolius</i> (syn.: <i>A. graecizans</i>)	Alfalfa mosaic virus Cucumber mosaic virus Potato virus X Potato virus Y Tobacco mosaic virus	Horváth (1975) Horváth (1975) Horváth (1976a) Horváth (1976a) Horváth (1975)
<i>A. ascendens</i> (syn.: <i>A. blitum</i>)	Alfalfa mosaic virus Cucumber mosaic virus Potato virus M Potato virus X Potato virus Y Tobacco mosaic virus Turnip mosaic virus	Horváth (1975) Horváth (1975) Horváth (1975) Horváth (1976b) Horváth (1976a) Horváth (1976a) Horváth (1975) Kovachevsky (1975)
<i>A. aspera</i>	Beet yellows virus	Schmelzer and Wolf (1977)
<i>A. atropurpureus</i>	Alfalfa mosaic virus Cucumber mosaic virus Potato virus M Potato virus X Potato virus Y Tobacco mosaic virus	Horváth (1975) Horváth (1975) Horváth (1976b) Horváth (1976a) Horváth (1976a) Horváth (1975)
<i>A. aureus</i>	Alfalfa mosaic virus Beet mosaic virus Beet yellows virus Cucumber mosaic virus Potato virus X Potato virus Y Tobacco mosaic virus	Horváth (1975, 1981) Schmelzer and Wolf (1977) Thornberry (1966) Horváth (1975) Horváth (1976a) Horváth (1976a) Horváth (1975)
<i>A. aurora</i>	Plum line pattern virus	Schmelzer and Wolf (1977)
<i>A. blitoides</i>	Alfalfa mosaic virus	Horváth (1975)
<i>A. blitum</i> (syn.: <i>A. ascendens</i>)	<i>Amaranthus</i> mosaic virus ¹ Cucumber mosaic virus Pingweed mosaic virus Potato virus X Tobacco mosaic virus	Phatak (1965) Horváth (1975) Singh et al. (1972) Nagaich and Upreti (1965) Horváth (1975)
<i>A. bouchonii</i>	Alfalfa mosaic virus	Horváth (1981)

Table 1 (continued)

<i>Amaranthus</i> species	Viruses*	Literature
<i>A. caracu</i>	Beet necrotic yellow vein virus	Horváth (1991a)
	Belladonna mottle virus	Horváth (1991a)
	Broad bean wilt virus	Horváth (1991a)
	Cucumber mosaic virus	Horváth (1975, 1991a)
	Henbane mosaic virus	Horváth (1991a)
	Potato virus M	Horváth (1976b)
	Potato virus X	Horváth (1976a, 1991a)
	Potato virus Y	Horváth (1976a, 1991a)
	Tobacco mosaic virus	Horváth (1975)
	Tobacco rattle virus	Horváth (1991a)
	Tobacco ringspot virus	Horváth (1991a)
	Tomato aspermy virus	Horváth (1991a)
	Tomato mosaic virus	Horváth (1991a)
	Zucchini yellow mosaic virus	Horváth (1991a)
	Alfalfa mosaic virus	Horváth (1975)
	Beet yellows virus	Thornberry (1966), Schmelzer and Wolf (1977)
	Cucumber mosaic virus	Horváth (1975)
	Potato virus M	Horváth (1976b)
	Potato virus X	Horváth (1976a)
	Potato virus Y	Horváth (1976a)
	Tobacco mosaic virus	Horváth (1975)
	Tomato black ring virus	Thornberry (1966), Schmelzer and Wolf, (1977), Edwardson and Christie (1986b)
<i>A. carneus</i>	Beet yellows virus	Thornberry (1966), Schmelzer and Wolf (1977)
<i>A. caudatus</i> (<i>A. cruentus</i>)	Alfalfa mosaic virus	Price (1940)
	<i>Amaranthus</i> leaf mottle virus	Casetta et al. (1986)
	<i>Amaranthus</i> mosaic virus ¹	Gowindaswamy et al. (1967)
	Andean potato latent virus	Fribourg et al. (1977)
	Anemone brown ring virus	Hollings (1958)
	Anemone mosaic virus	Hollings (1957)
	<i>Arabis</i> mosaic virus	Schmelzer and Wolf (1977)
	<i>Arracacha</i> virus A	Jones and Kenten (1978)
	<i>Arracacha</i> virus B	Kenten and Jones (1979)
	Artichoke Italian latent virus	Savino et al. (1977)
	Bean yellow mosaic virus	Hollings (1959)
	Beet curly top	Thornberry (1966)
	Beet mosaic virus	Russel (1971)
	Beet yellows virus	Schmelzer and Wolf (1977)
	Black locust true virus	Boswell and Gibbs (1983)
	Broad bean wilt virus	Schmelzer (1960)
	<i>Cactus</i> virus X	Bercks (1971), Attathom et al. (1978)
	Cabbage black ring virus ²	Brčak and Procházková (1976)
	Carnation Italian ringspot virus	Hollings et al. (1970)
	Carnation mottle virus	Hollings and Stone (1965)
	Carnation ringspot virus	Hollings and Stone (1965)

Table 1 (continued)

<i>Amaranthus</i> species	Viruses*	Literature
	Carnation vein mottle virus	Hollings (1959)
	Celery latent virus	Bos et al. (1978)
	Celery yellow vein virus ³	Hollings (1965)
	<i>Chrysanthemum</i> latent virus	Schmelzer and Wolf (1977)
	Cowpea aphid-borne mosaic virus	Quantz (1968)
	Clover yellow mosaic virus	Boswell and Gibbs (1983)
	Clover yellow vein virus	Lisa and Dellavalle (1983)
	Cucumber mosaic virus	Price (1940), Horváth and Szirmai (1973), Sharma and Chowfla (1987)
	<i>Cymbidium</i> ringspot virus	Hollings and Stone (1965)
	<i>Dahlia</i> mosaic virus	Brunt (1971)
	Dogwood mosaic virus	Barnett et al. (1989)
	Elderberry carlavirus	Van Lent et al. (1980)
	Elm mottle virus	Schmelzer and Wolf (1977)
	Grapevine fanleaf virus	Schmelzer and Wolf (1977)
	<i>Heracleum</i> latent virus	Bem and Murrant (1979)
	<i>Humulus japonicus</i> virus	Adams et al. (1989)
	<i>Hydrangea</i> ringspot virus	Schmelzer and Wolf (1977)
	<i>Iris fulva</i> mosaic virus	Barnett and Alper (1977), Barnett (1986)
	<i>Iris</i> mild mosaic virus	Schmelzer and Wolf (1977)
	<i>Iris</i> mosaic virus	Brunt (1968)
	<i>Lamium</i> mild mosaic virus ⁴	Lisa et al. (1982b)
	Lettuce mosaic virus	Hollings (1959)
	<i>Narcissus</i> mosaic virus	Schmelzer and Wolf (1977)
	<i>Narcissus</i> tip necrosis virus	Mowat et al. (1977)
	Okra mosaic virus	Givord (1979)
	Pea common mosaic virus	Hollings (1959)
	Pea early browning virus	Schmelzer and Wolf (1977)
	Pea mosaic virus	Hollings (1959)
	Peanut stunt virus	Waterworth et al. (1973), Boswell and Gibbs (1983)
	<i>Pelargonium</i> leaf curl virus	Hollings and Stone (1965)
	Pepper veinial mottle virus	Brunt and Kenten (1970), Atiri (1986)
	Pingweed mosaic virus	Singh et al. (1972)
	Plantain virus X	Hammond and Hull (1981)
	Potato black ringspot virus	Salazar and Harrison (1978)
	Potato leafroll virus	Schmelzer and Wolf (1977), Harrison (1984)
	Potato virus N ⁷	Agur (1975)
	Potato virus X	Horváth (1976a), Moreira et al. (1980)
	Potato virus Y	Horváth (1976a)
	Raspberry bushy dwarf virus	Schmelzer and Wolf (1977)
	Red clover necrotic mosaic virus	Boswell and Gibbs (1983)
	Red clover vein mosaic virus	Schmelzer and Wolf (1971)
	<i>Robinia</i> mosaic virus	Schmelzer and Wolf (1977)
	Sowbane mosaic virus	Schmelzer and Wolf (1977)

Table 1 (continued)

<i>Amaranthus</i> species	Viruses*	Literature
	Strawberry latent ringspot virus	Schmelzer and Wolf (1977)
	Tobacco etch virus	Hollings (1959)
	Tobacco mosaic virus	Schmelzer and Wolf (1977)
	Tobacco necrosis virus	Price (1940)
	Tobacco rattle virus	Schmelzer (1957)
	Tobacco ringspot virus	Price (1940)
	Tomato aspermy virus	Schmelzer and Wolf (1977)
	Tomato black ring virus	Schmelzer and Wolf (1977)
	Tomato bushy stunt virus	Hollings and Stone (1965)
	Tomato spotted wilt virus	Best (1968)
	<i>Tropaeolum</i> mosaic virus ¹	Delhey and Monasterios (1977)
	Turnip crinkle virus	Hollings and Stone (1965)
	Turnip mosaic virus	Thornberry (1966), Lisa and Lovisolo (1976)
	UV-potexvirus ¹	Fudl-Allah et al. (1983)
	<i>Viola</i> mottle virus	Lisa and Dellavalle (1977), Lisa et al. (1982a)
	Watermelon mosaic virus (strain 2)	Molnár and Schmelzer (1964)
	White clover virus	Hollings and Stone (1965)
<i>A. caudatus</i> cv. <i>Atropurpureus</i>	Alfalfa mosaic virus	Horváth (1975)
	Cucumber mosaic virus	Horváth (1975)
	Potato virus M	Horváth (1976b)
	Potato virus X	Horváth (1976a)
	Potato virus Y	Horváth (1976a)
<i>A. chlorostachys</i>	Tobacco mosaic virus	Horváth (1975)
	Alfalfa mosaic virus	Horváth (1975)
	Cucumber mosaic virus	Horváth (1975)
	Potato virus X	Horváth (1976a)
<i>A. chlorostachys</i> f. <i>strictus</i>	Tobacco mosaic virus	Horváth (1975)
	Alfalfa mosaic virus	Horváth (1975)
	Cucumber mosaic virus	Horváth (1975)
	Potato virus M	Horváth (1976b)
<i>A. chlorostachys</i> var. <i>powellii</i>	Tobacco mosaic virus	Horváth (1975)
	Alfalfa mosaic virus	Horváth (1975)
	Cucumber mosaic virus	Horváth (1975)
	Potato virus X	Horváth (1976a)
<i>A. cruentus</i> (syn.: <i>A. caudatus</i>)	Tobacco mosaic virus	Horváth (1975)
	Alfalfa mosaic virus	Horváth (1975, 1981)
	<i>Amaranthus</i> mosaic virus ¹	Phatak (1965)
	Beet yellows virus	Schmelzer and Wolf (1977)
	Cucumber mosaic virus	Horváth (1975, 1981)
	Pingweed mosaic virus	Singh et al. (1972)
	Potato virus M	Horváth (1976b)
	Potato virus X	Horváth (1976a)
	Potato virus Y	Horváth (1976a)
<i>A. deflexus</i>	Tobacco mosaic virus	Horváth (1975)
	<i>Amaranthus</i> leaf mottle virus	Lovisolo and Lisa (1976, 1979)
	Beet curly top virus	Thornberry (1966)
	Beet yellows virus	Schmelzer and Wolf (1977)

Table 1 (continued)

<i>Amaranthus</i> species	Viruses*	Literature
	Cucumber mosaic virus	Horváth (1979, 1983b)
	Potato virus X	Horváth (1976a)
	Tobacco mosaic virus	Horváth (1975)
	UV ¹	Gracia and Feldman (1972)
<i>A. deflexus</i> var. <i>rufescens</i>	Potato virus Y	Horváth (1976a)
	Tobacco mosaic virus	Horváth (1975)
<i>A. dubius</i>	Alfalfa mosaic virus	Horváth (1975, 1981)
	Cucumber mosaic virus ¹⁰	Horváth (1975, 1981)
	Papaya ringspot virus	Sanchez de Luque and Martinez-López (1977)
	Pingweed mosaic virus	Singh et al. (1972)
	Potato virus M	Horváth (1976b)
	Potato virus X	Horváth (1976a)
	Potato virus Y	Horváth (1976a)
	Tobacco mosaic virus	Horváth (1975)
<i>A. edulis</i>	Andean potato latent virus	Fribourg et al. (1977)
	<i>Arracacha</i> virus B	Kenten and Jones (1979)
	Maracuja (<i>Passiflora edulis</i>) mosaic virus	Fribourg et al. (1987)
	Potato virus X	Nagaich and Upreti (1965)
<i>A. emarginatus</i>	Alfalfa mosaic virus	Horváth (1975)
	Cucumber mosaic virus	Horváth (1975)
	Potato virus X	Horváth (1976a)
	Tobacco mosaic virus	Horváth (1975)
<i>A. flavus</i>	Broad bean wilt virus	Schmelzer and Stahl (1977), Edwardson and Christie (1986a)
<i>A. gangeticus</i> (syn.: <i>A. tricolor</i>)	<i>Amaranthus</i> mosaic virus ¹	Govindaswamy et al. (1967)
	Beet curly top virus	Thornberry (1966)
	Beet yellows virus	Thornberry (1966)
	Cucumber mosaic virus	Horváth (1975)
	Pingweed mosaic virus	Singh et al. (1972)
	Potato aucuba mosaic virus	De Bokx (1975), Schmelzer and Wolf (1977)
	Potato virus X	Thornberry (1966)
	Tobacco ringspot virus	Sastry and Nayudu (1976)
<i>A. gangeticus</i> var. <i>multicolor</i> hort.	Alfalfa mosaic virus	Horváth (1975)
	Cucumber mosaic virus	Horváth (1975)
	Potato virus M	Horváth (1976b)
	Potato virus X	Horváth (1976a)
	Potato virus Y	Horváth (1976a)
	Tobacco mosaic virus	Horváth (1975)
<i>A. gracilis</i>	<i>Amaranthus</i> mottle virus ¹	Qureshi and Mahmood (1980)
<i>A. graecizans</i> (syn.: <i>A. angustifolius</i>)	Alfalfa mosaic virus	Horváth (1975)
	Beet curly top virus	Thornberry (1966)
	Beet yellows virus	Thornberry (1966)
	Cucumber mosaic virus	Horváth (1975)
	Plum line pattern virus	Schmelzer and Wolf (1977)
	Potato leafroll virus	Schmelzer and Wolf (1977)
	Potato virus X	Horváth (1976a)
	Potato virus Y	Horváth (1976a)
	Tobacco mosaic virus	Holmes (1938)

Table 1 (continued)

<i>Amaranthus</i> species	Viruses*	Literature
	Tomato black ring virus	Edwardson and Christie (1986b)
	Tomato spotted wilt virus	Best (1968), Edwardson and Christie (1986c)
<i>A. hybridus</i>	Alfalfa mosaic virus	Kaiser and Robertson (1976)
	<i>Amaranthus</i> leaf mottle virus	Casetta et al. (1986)
	<i>Amaranthus</i> mosaic virus ¹	Taiwo (1988)
	Artichoke Italian latent virus	Savino et al. (1977)
	Broad bean wilt virus	Boccardo and Conti (1973)
	<i>Cactus</i> virus X	Schmelzer and Wolf (1977)
	Carnation mottle virus	Schmelzer and Wolf (1977)
	Carnation ringspot virus	Schmelzer and Wolf (1977)
	Cucumber mosaic virus	Schmelzer and Wolf (1977)
	Lettuce speckles virus ⁵	Falk et al. (1979)
	Potato virus X	MacLeod (1962)
	Tobacco mosaic virus	Schmelzer and Wolf (1977)
	Tobacco ringspot virus	Sammons and Barnett (1987)
	Tomato spotted wilt virus	Cho et al. (1986)
	<i>Viola</i> mottle virus	Lisa and Dellavalle (1977)
	<i>Wisteria</i> vein mosaic virus	Conti and Lovisolo (1969), Schmelzer and Wolf (1977)
<i>A. hybridus</i> spp. <i>incurvatus</i>	Alfalfa mosaic virus	Kaiser and Robertson (1976)
<i>A. hybridus</i> var. <i>hypochondriacus</i>	Broad bean wilt virus	Schmelzer and Wolf (1977)
	Celery latent virus	Brandes and Luisoni (1966), Bos et al. (1978)
<i>A. hypochondriacus</i>	Raspberry ringspot virus	Rana et al. (1985)
	Alfalfa mosaic virus	Horváth (1975, 1981)
	Cucumber mosaic virus	Horváth (1975, 1981)
	Potato virus M	Horváth (1976b)
	Potato virus X	Horváth (1976a)
	Potato virus Y	Horváth (1976a)
	Tobacco mosaic virus	Horváth (1975, 1981)
<i>A. hypochondriacus</i> cv. <i>Monstrosus</i>	Alfalfa mosaic virus	Horváth (1975)
	Cucumber mosaic virus	Horváth (1975)
	Potato virus M	Horváth (1976b)
	Potato virus X	Horváth (1976a)
	Potato virus Y	Horváth (1976a)
	Tobacco mosaic virus	Horváth (1975)
<i>A. leucocarpus</i>	Alfalfa mosaic virus	Nagaich and Giri (1968), Horváth (1975)
	<i>Amaranthus</i> mosaic virus ¹	Phatak (1965)
	Cucumber mosaic virus	Nagaich and Giri (1968), Horváth (1975)
	Pingweed mosaic virus	Singh et al. (1972)
	Potato virus M	Horváth (1976b)
	Potato virus X	Nagaich and Upreti (1965), Horváth (1976a)
<i>A. lividus</i>	Potato virus Y	Horváth (1976a)
	Alfalfa mosaic virus	Horváth (1975), Schmelzer (1970)
	<i>Amaranthus lividus</i> virus ¹	Rubio-Huertos and Vela-Cornejo (1966)

Table 1 (continued)

<i>Amaranthus</i> species	Viruses*	Literature
	Beet yellows virus	Horváth (1975), Schmelzer and Wolf (1977)
	Broad bean wilt virus	Rist and Lorbeer (1989)
	<i>Cactus</i> virus X	Schmelzer and Wolf (1977)
	Cucumber mosaic virus	Horváth (1975), Rist and Lorbeer (1989)
	Potato virus X	Horváth (1976a)
	Potato virus Y	Horváth (1976a)
	Strawberry latent ringspot virus	Schmelzer and Wolf (1977)
	Tobacco mosaic virus	Schmelzer and Wolf (1977)
	Watermelon mosaic virus (strain 2)	Yohana et al. (1977)
<i>A. lividus</i> var. <i>ascendens</i>	<i>Amaranthus lividus</i> mottle virus ¹	Schmelzer and Wolf (1977)
<i>A. mangostanus</i>	<i>Amaranthus</i> mosaic virus ¹	Phatak (1965)
	Beet necrotic yellow vein virus	Horváth (1990b)
	Belladonna mottle virus	Horváth (1991b)
	Broad bean wilt virus	Horváth (1991b)
	Cucumber mosaic virus	Horváth (1991b)
	Henbane mosaic virus	Horváth (1991b)
	Pingweed mosaic virus	Singh et al. (1972)
	Potato virus X	Horváth (1991b)
	Potato virus Y	Horváth (1991b)
	Tobacco rattle virus	Horváth (1991b)
	Tobacco ringspot virus	Horváth (1991b)
	Tomato aspermy virus	Horváth (1991b)
	Tomato mosaic virus	Horváth (1991b)
	Zucchini yellow mosaic virus	Horváth (1991b)
<i>A. mantegazzianus</i>	Alfalfa mosaic virus	Horváth (1975)
	Cucumber mosaic virus	Horváth (1975)
	Potato virus M	Horváth (1976b)
	Potato virus X	Horváth (1976a)
	Potato virus Y	Horváth (1976a)
<i>A. mitchellii</i>	Belladonna mottle virus	Horváth (1991b)
	Broad bean wilt virus	Horváth (1991b)
	Cucumber mosaic virus	Horváth (1991b)
	Henbane mosaic virus	Horváth (1991b)
	Potato virus X	Horváth (1991b)
	Potato virus Y	Horváth (1991b)
	Tobacco rattle virus	Horváth (1991b)
	Tobacco ringspot virus	Horváth (1991b)
	Tomato aspermy virus	Horváth (1991b)
	Tomato mosaic virus	Horváth (1991b)
	Zucchini yellow mosaic virus	Horváth (1991b)
<i>A. monstrosus</i>	Beet mosaic virus	Schmelzer and Wolf (1977)
<i>A. oleraceus</i>	Alfalfa mosaic virus	Horváth (1975)
	Cucumber mosaic virus	Horváth (1975)
	Potato virus M	Horváth (1976b)
	Potato virus X	Horváth (1976a)

Table 1 (continued)

<i>Amaranthus</i> species	Viruses*	Literature
<i>A. palmeri</i>	Potato virus Y	Horváth (1976a)
	Beet yellows virus	Schmelzer and Wolf (1977)
<i>A. paniculatus</i>	Tobacco ringspot virus	MacLean (1962b)
	Alfalfa mosaic virus	Horváth (1975)
	Beet mosaic virus	Schmelzer and Wolf (1977)
	Beet yellows virus	Schmelzer and Wolf (1977)
	Carnation ringspot virus	Schmelzer and Wolf (1977)
	Cucumber mosaic virus	Horváth (1975)
	Potato virus M	Horváth (1976b)
	Potato virus X	Horváth (1976a)
	Potato virus Y	Horváth (1976a)
	Tobacco broad ringspot virus ⁹	Thornberry (1966)
	Tobacco mosaic virus	Horváth (1975)
	Tobacco necrosis virus	Kegler et al. (1969), Edwardson and Christie (1986c)
	Tobacco ringspot virus	Wingard (1928)
	Tobacco stunt virus	Hiruki (1975)
<i>A. paniculatus</i> var. <i>cruentus</i>	Tomato black ring virus	Schmelzer and Wolf (1977)
	Turnip mosaic virus	Kovachevsky (1975)
<i>A. paniculatus</i> var. <i>flavescens</i>	<i>Cactus</i> virus X	Schmelzer and Wolf (1977)
<i>A. paniculatus</i> var. <i>flavus</i>	<i>Cactus</i> virus X	Schmelzer and Wolf (1977)
	Alfalfa mosaic virus	Horváth (1975)
	Cucumber mosaic virus	Horváth (1975)
	Potato virus M	Horváth (1976b)
	Potato virus X	Horváth (1976a)
	Potato virus Y	Horváth (1976a)
	Tobacco mosaic virus	Horváth (1975)
	Alfalfa mosaic virus	Horváth (1975)
	Cucumber mosaic virus	Horváth (1975)
	Potato virus M	Horváth (1976b)
	Potato virus X	Horváth (1976a)
<i>A. paniculatus</i> cv. <i>Roter Dom</i>	Potato virus Y	Horváth (1976a)
	Tobacco mosaic virus	Horváth (1975)
	Alfalfa mosaic virus	Horváth (1975)
	Cucumber mosaic virus	Horváth (1975)
<i>A. paniculatus</i> cv. <i>Roter Paris</i>	Potato virus M	Horváth (1976b)
	Potato virus X	Horváth (1976a)
	Potato virus Y	Horváth (1976a)
	Tobacco mosaic virus	Horváth (1975)
	Alfalfa mosaic virus	Horváth (1975)
	Cucumber mosaic virus	Horváth (1975)
<i>A. paniculatus</i> cv. <i>Sanguineus nanus</i>	Potato virus X	Horváth (1976a)
	Potato virus Y	Horváth (1976a)
	Tobacco mosaic virus	Horváth (1975)
	Alfalfa mosaic virus	Horváth (1975)
	Cucumber mosaic virus	Horváth (1975)
	Potato virus X	Horváth (1976a)
<i>A. patulus</i>	Potato virus Y	Horváth (1976a)
	Tobacco mosaic virus	Horváth (1975)
	Alfalfa mosaic virus	Horváth (1975)
	Beet yellows virus	Schmelzer and Wolf (1977)
	Cucumber mosaic virus	Horváth (1975)
	Grapevine fanleaf virus	Schmelzer and Wolf (1977)
	Potato virus X	Horváth (1976a)
	Potato virus Y	Horváth (1976a)
	Tobacco mosaic virus	Horváth (1975)

Table 1 (continued)

<i>Amaranthus</i> species	Viruses*	Literature
<i>A. powellii</i>	Tobacco rattle virus	Locatelli et al. (1978)
<i>A. quitensis</i>	Belladonna mottle virus	Horváth (1991b)
	Broad bean wilt virus	Horváth (1991b)
	Cucumber mosaic virus	Horváth (1991b)
	Henbane mosaic virus	Horváth (1991b)
	Potato virus X	Horváth (1991b)
	Potato virus Y	Horváth (1991b)
	Tobacco rattle virus	Horváth (1991b)
	Tobacco ringspot virus	Horváth (1991b)
	Tomato aspermy virus	Horváth (1991b)
	Tomato mosaic virus	Horváth (1991b)
	UV ^{1,5}	Gracia and Feldman (1972)
<i>A. retroflexus</i>	Zucchini yellow mosaic virus	Horváth (1991b)
	Alfalfa mosaic virus	Schmelzer (1963), Horváth (1975)
	Apple stem grooving virus	Németh (1986)
	<i>Arabis</i> mosaic virus	Klinkowski and Uschdraweit (1968)
	Artichoke Italian latent virus	Savino et al. (1977)
	<i>Asparagus</i> virus 2	Weissenfels et al. (1978)
	Barley stripe mosaic virus	Schmelzer and Wolf (1977)
	Beet curly top virus	Thornberry (1966)
	Beet mosaic virus	Russel (1971)
	Beet western yellows virus	Boswell and Gibbs (1983), Timmerman et al. (1985)
	Beet yellows virus	Gorjushin (1964)
	Broad bean wilt virus	Schmelzer (1960), Weidemann et al. (1975), Jankulowa and Kaitazowa (1979)
	<i>Cactus</i> virus X	Schmelzer and Wolf (1977)
	Carnation mottle virus	Schmelzer and Wolf (1977)
	Carnation ringspot virus	Schmelzer and Wolf (1977)
	Celery latent virus	Brandes and Luisoni (1966), Bos et al. (1978)
	Cucumber mosaic virus	Doolittle and Walker (1923), Hein (1957), Dashkeeva et al. (1966), Häni (1971), Schmelzer and Molnár (1975)
	Elm mottle virus	Schmelzer and Wolf (1977)
	Grapevine fanleaf virus	Schmelzer and Wolf (1977)
	<i>Hydrangea</i> ringspot virus	Schmelzer and Wolf (1977)
	<i>Iris</i> ringspot virus	Thornberry (1966)
	Large nettle yellow mottle virus	Schmelzer and Wolf (1977)
	Lilac chlorotic leafspot virus	Brunt (1978)
	Okra mosaic virus	Givord (1979)
	Pepper veinal mottle virus	Atiri (1986)
	<i>Plantago</i> severe mottle virus	Rowhani and Peterson (1980)
	Potato aucuba mosaic virus	MacLeod (1962)
	Potato leafroll virus	Lebedeva (1975), Horváth (1976a), Locatelli et al. (1978)
	Potato virus M	Horváth (1976b)

Table 1 (continued)

<i>Amaranthus</i> species	Viruses*	Literature
	Potato virus X	MacLeod (1962), Horváth (1975), Horváth (1976a)
	Prunus necrotic ringspot virus	Smith and Skotland (1986)
	Spinach latent virus	Štefanac and Wrisher (1983)
	Strawberry latent ringspot virus	Hein (1957), Dashkeeva et al. (1966), Háni (1971), Schmelzer and Molnár (1975)
	Tobacco broad ringspot virus ⁹	Thornberry (1966)
	Tobacco mosaic virus	Horváth (1975)
	Tobacco rattle virus	Locatelli et al. (1978)
	Tobacco ringspot virus	McLean (1962a)
	Tomato black ring virus	Schmelzer and Wolf (1977)
	Tomato ringspot virus	Schmelzer and Wolf (1977)
	Tomato spotted wilt virus	Milbrath (1939)
	Turnip mosaic virus	Kovachevsky (1975)
<i>A. silvester</i>	<i>Cactus</i> virus X	Schmelzer and Wolf (1977)
<i>A. speciosus</i>	Alfalfa mosaic virus	Horváth (1975)
	Beet yellows virus	Schmelzer and Wolf (1977)
	Cucumber mosaic virus	Horváth (1975)
	Potato virus M	Horváth (1976b)
	Potato virus X	Horváth (1976a)
	Potato virus Y	Horváth (1976a)
	Tobacco mosaic virus	Horváth (1975)
<i>A. spinosus</i>	Alfalfa mosaic virus	Horváth (1975)
	Cucumber mosaic virus	Horváth (1975)
	Pingweed mosaic virus	Singh et al. (1972)
	Potato virus M	Horváth (1976b)
	Potato virus X	Horváth (1976a)
	Potato virus Y	Horváth (1976a)
	Tobacco bushy-top virus ¹¹	Chapola (1980)
	Tobacco mosaic virus	Horváth (1975), Schmelzer and Wolf (1977)
	Tomato spotted wilt virus	Cho et al. (1986)
<i>A. sylvestris</i>	Alfalfa mosaic virus	Horváth (1975)
	Cucumber mosaic virus	Horváth (1975)
	Potato virus M	Horváth (1976b)
	Potato virus X	Horváth (1976a)
	Potato virus Y	Horváth (1976a)
	Tobacco mosaic virus	Horváth (1975)
<i>A. tricolor</i> (syn.: <i>A. gangeticus</i>)	Alfalfa mosaic virus	Horváth (1975)
	<i>Amaranthus</i> leaf mottle virus	Casetta et al. (1986)
	Apple stem grooving virus	Sawamura and Osada (1980)
	Artichoke latent virus	Rana et al. (1982)
	Artichoke yellow ringspot virus	Rana et al. (1980)
	Cucumber mosaic virus	Price (1940), Horváth (1969), Schmelzer and Wolf (1977)
	Potato virus M	Horváth (1976b)
	Potato virus X	MacLeod (1962), Horváth (1976a)
	Potato virus Y	MacLeod (1962), Horváth (1976a)

Table 1 (continued)

<i>Amaranthus</i> species	Viruses*	Literature
	Red currant ringspot virus ⁸	Thornberry (1966)
	Spinach latent virus	Van der Meer (1968)
	Tobacco mosaic virus	Holmes (1946)
	Tobacco ringspot virus	Schmelzer and Wolf (1977)
	Tomato ringspot virus	Thornberry (1966)
	Turnip mosaic virus	Price (1940), Horváth (1969), Schmelzer and Wolf (1977)
<i>A. tricolor</i> cv. <i>Malten Fire</i>	Alfalfa mosaic virus	Horváth (1975)
	Cucumber mosaic virus	Horváth (1975)
	Potato virus X	Horváth (1976a)
	Potato virus Y	Horváth (1976a)
	Tobacco mosaic virus	Horváth (1975)
<i>A. tricolor</i> var. <i>splendens</i>	Tobacco ringspot virus	Tuite (1960)
<i>A. viridis</i>	Alfalfa mosaic virus	Horváth (1975)
	<i>Amaranthus</i> mosaic virus ¹	Phatak (1965)
	Artichoke Italian latent virus	Savino et al. (1977)
	Cucumber mosaic virus	Horváth (1979)
	Eggplant mottled crinkle virus	Raj et al. (1989)
	Pingweed mosaic virus	Singh et al. (1972), Shamsher and Verma (1976)
	Potato virus M	Horváth (1976b)
	Potato virus X	Horváth (1976a)
	Potato virus Y	Horváth (1976a)
	Tobacco mosaic virus	Horváth (1975)
	Tomato spotted wilt virus	Cho et al. (1986)

*Key to numbers by viruses: 1 – exactly unidentified virus(es), 2 – strain of turnip mosaic virus, 3 – strain of tomato black ring virus, 4 – related to broad bean wilt virus, 5 – pathogenic after aphid transmission but not mechanically, 6 – strain of tobacco mosaic virus, 7 – strain of cucumber mosaic virus, 8 – syn.: raspberry ringspot virus, 9 – strain of cucumber mosaic virus, or more likely one of the nematode-transmitted viruses, 10 – after Migliori et al. (1978) is not pathogenic to *Amaranthus dubius*, 11 – constituents: tobacco vein distorting and tobacco mottle viruses

Viruses and their *Amaranthus* hosts

For the sake of a better survey we have compiled a table for the *Amaranthus* host of the individual viruses (Table 3). As seen from the table the following viruses have the largest number of *Amaranthus* hosts known: cucumber mosaic virus (42), potato virus X (42), alfalfa mosaic virus (39), tobacco mosaic virus (35), potato virus Y (34). There are viruses (e.g. *Arracacha* virus A, carnation Italian ringspot virus, papaya ringspot virus, *Wisteria* vein mosaic virus etc.) known so far to have a single *Amaranthus* host each.

Table 2

Number of viruses infected *Amaranthus* species

<i>Amaranthus</i> species	Number of viruses	<i>Amaranthus</i> species	Number of viruses
<i>Amaranthus</i> ssp.	5	<i>A. hybridus</i> var. <i>hypochondriacus</i>	3
<i>A. albus</i>	5	<i>A. hypochondriacus</i>	6
<i>A. albus</i> var. <i>roseus</i>	1	<i>A. hypochondriacus</i> cv. <i>Monstrosus</i>	6
<i>A. angustifolius</i> (syn.: <i>A. graecizans</i>)	5	<i>A. leucocarpus</i>	7
<i>A. ascendens</i> (syn.: <i>A. blitum</i>)	7	<i>A. lividus</i>	11
<i>A. aspera</i>	1	<i>A. lividus</i> var. <i>ascendens</i>	1
<i>A. atropurpureus</i>	6	<i>A. mangostanus</i>	14
<i>A. aureus</i>	7	<i>A. mantegazzianus</i>	5
<i>A. aurora</i>	1	<i>A. mitchellii</i>	11
<i>A. blitoides</i>	1	<i>A. monstrosus</i>	1
<i>A. blitum</i> (syn.: <i>A. ascendens</i>)	5	<i>A. oleraceus</i>	5
<i>A. bouchonii</i>	15	<i>A. palmeri</i>	2
<i>A. caracu</i>	8	<i>A. paniculatus</i>	16
<i>A. carneus</i>	1	<i>A. paniculatus</i> var. <i>cruentus</i>	1
<i>A. caudatus</i> (<i>A. cruentus</i>)	84	<i>A. paniculatus</i> var. <i>flavescens</i>	1
<i>A. caudatus</i> cv. <i>Atropurpureus</i>	6	<i>A. paniculatus</i> var. <i>flavus</i>	6
<i>A. chlorostachys</i>	4	<i>A. paniculatus</i> cv. <i>Roter Dom</i>	6
<i>A. chlorostachys</i> f. <i>strictus</i>	4	<i>A. paniculatus</i> cv. <i>Roter Paris</i>	5
<i>A. chlorostachys</i> var. <i>powellii</i>	4	<i>A. paniculatus</i> cv. <i>Sanguineus nanus</i>	5
<i>A. cruentus</i> (syn.: <i>A. caudatus</i>)	9	<i>A. patulus</i>	7
<i>A. deflexus</i>	7	<i>A. powellii</i>	1
<i>A. deflexus</i> var. <i>rufescens</i>	2	<i>A. quitensis</i>	12
<i>A. dubius</i>	8	<i>A. retroflexus</i>	40
<i>A. edulis</i>	4	<i>A. silvester</i>	1
<i>A. emerginatus</i>	4	<i>A. speciosus</i>	7
<i>A. flavus</i>	1	<i>A. spinosus</i>	9
<i>A. gangeticus</i> (syn.: <i>A. tricolor</i>)	8	<i>A. sylvestris</i>	6
<i>A. gangeticus</i> var. <i>multicolor</i> hort.	6	<i>A. tricolor</i> (syn.: <i>A. gangeticus</i>)	15
<i>A. gracilis</i>	1	<i>A. tricolor</i> cv. <i>Malten Fire</i>	5
<i>A. graecizans</i> (syn.: <i>A. angustifolius</i>)	11	<i>A. tricolor</i> var. <i>splendens</i>	1
<i>A. hybridus</i>	16	<i>A. viridis</i>	11
<i>A. hybridus</i> ssp. <i>incurvatus</i>	1		

Table 3

Viruses and their *Amaranthus* hosts

Viruses*	<i>Amaranthus</i> hosts
Alfalfa mosaic virus	<i>Amaranthus albus</i> <i>A. angustifolius</i> (syn.: <i>A. graecizans</i>) <i>A. ascendens</i> (syn.: <i>A. blitum</i>) <i>A. atropurpureus</i> <i>A. aureus</i> <i>A. blitoides</i> <i>A. bouchonii</i> <i>A. caracu</i> <i>A. caudatus</i> (<i>A. cruentus</i>) <i>A. caudatus</i> cv. <i>Atropurpureus</i> <i>A. chlorostachys</i> <i>A. chlorostachys</i> f. <i>strictus</i> <i>A. chlorostachys</i> var. <i>powellii</i> <i>A. cruentus</i> (syn.: <i>A. caudatus</i>) <i>A. dubius</i> <i>A. emarginatus</i> <i>A. gangeticus</i> var. <i>multicolor</i> hort. <i>A. graecizans</i> (syn.: <i>A. angustifolius</i>) <i>A. hybridus</i> <i>A. hybridus</i> ssp. <i>incurvatus</i> <i>A. hypochondriacus</i> <i>A. hypochondriacus</i> cv. <i>Monstrosus</i> <i>A. leucocarpus</i> <i>A. lividus</i> <i>A. mantegazzianus</i> <i>A. oleraceus</i> <i>A. paniculatus</i> <i>A. paniculatus</i> var. <i>flavus</i> <i>A. paniculatus</i> cv. <i>Roter Dom</i> <i>A. paniculatus</i> cv. <i>Roter Paris</i> <i>A. paniculatus</i> cv. <i>Sanguineus nanus</i> <i>A. patulus</i> <i>A. retroflexus</i> <i>A. speciosus</i> <i>A. spinosus</i> <i>A. sylvestris</i> <i>A. tricolor</i> (syn.: <i>A. gangeticus</i>) <i>A. tricolor</i> cv. <i>Malten Fire</i> <i>A. viridis</i> <i>A. caudatus</i> (<i>A. cruentus</i>) <i>A. deflexus</i> <i>A. hybridus</i> <i>A. tricolor</i> (syn.: <i>A. gangeticus</i>) <i>A. lividus</i> <i>A. lividus</i> var. <i>ascendens</i> <i>A. blitum</i> (syn.: <i>A. ascendens</i>) <i>A. caudatus</i> (<i>A. cruentus</i>) <i>A. cruentus</i> (syn.: <i>A. caudatus</i>) <i>A. gangeticus</i> (syn.: <i>A. tricolor</i>)
<i>Amaranthus</i> leaf mottle virus	
<i>Amaranthus lividus</i> virus ¹	
<i>Amaranthus lividus</i> mottle virus	
<i>Amaranthus</i> mosaic virus ¹	

Table 3 (continued)

Viruses*	<i>Amaranthus</i> hosts
	<i>A. hybridus</i>
	<i>A. leucocarpus</i>
	<i>A. mangostanus</i>
	<i>A. viridis</i>
<i>Amaranthus</i> mottle virus ¹	<i>A. ssp.</i>
	<i>A. gracilis</i>
Andean potato latent virus	<i>A. caudatus</i> (<i>A. cruentus</i>)
	<i>A. edulis</i>
<i>Anemone</i> brown ring virus	<i>A. caudatus</i> (<i>A. cruentus</i>)
<i>Anemone</i> mosaic virus	<i>A. caudatus</i> (<i>A. cruentus</i>)
Apple stem grooving virus	<i>A. retroflexus</i>
	<i>A. tricolor</i> (syn.: <i>A. gangeticus</i>)
<i>Arabis</i> mosaic virus	<i>A. caudatus</i> (<i>A. cruentus</i>)
	<i>A. retroflexus</i>
<i>Arracacha</i> virus A	<i>A. caudatus</i> (<i>A. cruentus</i>)
<i>Arracacha</i> virus B	<i>A. caudatus</i> (<i>A. cruentus</i>)
	<i>A. edulis</i>
Artichoke Italian latent virus	<i>A. hybridus</i>
	<i>A. retroflexus</i>
	<i>A. tricolor</i> (syn.: <i>A. gangeticus</i>)
	<i>A. viridis</i>
Artichoke latent virus	<i>A. tricolor</i> (syn.: <i>A. gangeticus</i>)
Artichoke yellow ringspot virus	<i>A. tricolor</i> (syn.: <i>A. gangeticus</i>)
<i>Asparagus</i> virus 2	<i>A. retroflexus</i>
Barley stripe mosaic virus	<i>A. retroflexus</i>
Bean yellow mosaic virus	<i>A. caudatus</i> (<i>A. cruentus</i>)
Beet curly top virus	<i>A. caudatus</i> (<i>A. cruentus</i>)
	<i>A. deflexus</i>
	<i>A. gangeticus</i> (syn.: <i>A. tricolor</i>)
	<i>A. graecizans</i> (syn.: <i>A. angustifolius</i>)
	<i>A. retroflexus</i>
Beet mosaic virus	<i>A. albus</i>
	<i>A. albus</i> var. <i>roseus</i>
	<i>A. atropurpureus</i>
	<i>A. caudatus</i> (<i>A. cruentus</i>)
	<i>A. monstrosus</i>
	<i>A. paniculatus</i>
	<i>A. retroflexus</i>
Beet necrotic yellow vein virus	<i>A. bouchonii</i>
	<i>A. mangostanus</i>
Beet western yellows virus	<i>A. retroflexus</i>
Beet yellows virus	<i>A. albus</i>
	<i>A. aspera</i>
	<i>A. aureus</i>
	<i>A. caracu</i>
	<i>A. carneus</i>
	<i>A. caudatus</i> (<i>A. cruentus</i>)
	<i>A. cruentus</i> (syn.: <i>A. caudatus</i>)
	<i>A. deflexus</i>
	<i>A. gangeticus</i> (syn.: <i>A. tricolor</i>)

Table 3 (continued)

Viruses*	<i>Amaranthus</i> hosts
	<i>A. graecizans</i> (syn.: <i>A. angustifolius</i>)
	<i>A. lividus</i>
	<i>A. palmeri</i>
	<i>A. paniculatus</i>
	<i>A. patulus</i>
	<i>A. retroflexus</i>
	<i>A. speciosus</i>
Belladonna mottle virus	<i>A. bouchonii</i>
	<i>A. mangostanus</i>
	<i>A. mitchellii</i>
	<i>A. quitensis</i>
Black locust true virus	<i>A. caudatus</i> (<i>A. cruentus</i>)
Broad bean wilt virus	<i>A. albus</i>
	<i>A. bouchonii</i>
	<i>A. caudatus</i> (<i>A. cruentus</i>)
	<i>A. flavus</i>
	<i>A. hybridus</i>
	<i>A. hybridus</i> var. <i>hypochondriacus</i>
	<i>A. lividus</i>
	<i>A. mangostanus</i>
	<i>A. mitchellii</i>
	<i>A. quitensis</i>
	<i>A. retroflexus</i>
Cabbage black ring virus ²	<i>A. caudatus</i> (<i>A. cruentus</i>)
Cactus virus X	<i>A. caudatus</i> (<i>A. cruentus</i>)
	<i>A. hybridus</i>
	<i>A. lividus</i>
	<i>A. paniculatus</i> var. <i>cruentus</i>
	<i>A. paniculatus</i> var. <i>flavescens</i>
	<i>A. retroflexus</i>
	<i>A. silvester</i>
Carnation Italian ringspot virus	<i>A. caudatus</i> (<i>A. cruentus</i>)
Carnation mottle virus	<i>A. caudatus</i> (<i>A. cruentus</i>)
	<i>A. hybridus</i>
	<i>A. paniculatus</i>
	<i>A. retroflexus</i>
Carnation ringspot virus	<i>A. caudatus</i> (<i>A. cruentus</i>)
	<i>A. hybridus</i>
	<i>A. paniculatus</i>
	<i>A. retroflexus</i>
Carnation vein mottle virus	<i>A. caudatus</i> (<i>A. cruentus</i>)
Celery latent virus	<i>A. caudatus</i> (<i>A. cruentus</i>)
	<i>A. hybridus</i> var. <i>hypochondriacus</i>
	<i>A. retroflexus</i>
Celery yellow vein virus ³	<i>A. caudatus</i> (<i>A. cruentus</i>)
<i>Chrysanthemum</i> latent virus	<i>A. caudatus</i> (<i>A. cruentus</i>)
Clover yellow mosaic virus	<i>A. caudatus</i> (<i>A. cruentus</i>)
Clover yellow vein virus	<i>A. caudatus</i> (<i>A. cruentus</i>)
Cowpea aphid-borne mosaic virus	<i>A. caudatus</i> (<i>A. cruentus</i>)
Cowpea mosaic virus	<i>A. caudatus</i> (<i>A. cruentus</i>)

Table 3 (continued)

Viruses*	<i>Amaranthus</i> hosts
Cucumber mosaic virus	<i>A. angustifolius</i> (syn.: <i>A. graecizans</i>) <i>A. ascendens</i> (syn.: <i>A. blitum</i>) <i>A. atropurpureus</i> <i>A. aureus</i> <i>A. blitum</i> (syn.: <i>A. ascendens</i>) <i>A. bouchonii</i> <i>A. caracu</i> <i>A. caudatus</i> (<i>A. cruentus</i>) <i>A. caudatus</i> cv. <i>Atropurpureus</i> <i>A. chlorostachys</i> <i>A. chlorostachys</i> f. <i>strictus</i> <i>A. chlorostachys</i> var. <i>powellii</i> <i>A. cruentus</i> (syn.: <i>A. caudatus</i>) <i>A. deflexus</i> <i>A. dubius</i> <i>A. emarginatus</i> <i>A. gangeticus</i> (syn.: <i>A. tricolor</i>) <i>A. gangeticus</i> var. <i>multicolor</i> hort. <i>A. graecizans</i> (syn.: <i>A. angustifolius</i>) <i>A. hybridus</i> <i>A. hypochondriacus</i> <i>A. hypochondriacus</i> cv. <i>Monstrosus</i> <i>A. leucocarpus</i> <i>A. lividus</i> <i>A. mangostanus</i> <i>A. mantegazzianus</i> <i>A. mitchellii</i> <i>A. oleraceus</i> <i>A. paniculatus</i> <i>A. paniculatus</i> var. <i>flavus</i> <i>A. paniculatus</i> cv. <i>Roter Dom</i> <i>A. paniculatus</i> cv. <i>Roter Paris</i> <i>A. paniculatus</i> cv. <i>Sanquineus nanus</i> <i>A. patulus</i> <i>A. quitensis</i> <i>A. retroflexus</i> <i>A. speciosus</i> <i>A. spinosus</i> <i>A. sylvestris</i> <i>A. tricolor</i> (syn.: <i>A. gangeticus</i>) <i>A. tricolor</i> cv. <i>Malten Fire</i> <i>A. viridis</i>
Cymbidium ringspot virus	<i>A. caudatus</i> (<i>A. cruentus</i>)
Dahlia mosaic virus	<i>A. caudatus</i> (<i>A. cruentus</i>)
Dogwood mosaic virus	<i>A. caudatus</i>
Eggplant mottled crinkle virus	<i>A. viridis</i>
Elderberry carlavirus	<i>A. caudatus</i> (<i>A. cruentus</i>)
Elm mottle virus	<i>A. caudatus</i> (<i>A. cruentus</i>) <i>A. retroflexus</i>

Table 3 (continued)

Viruses*	<i>Amaranthus</i> hosts
Grapevine fanleaf virus	<i>A. caudatus</i> (<i>A. cruentus</i>) <i>A. retroflexus</i> <i>A. patulus</i>
Henbane mosaic virus	<i>A. bouchonii</i> <i>A. mangostanus</i> <i>A. mitchellii</i> <i>A. quitensis</i>
<i>Heracleum</i> latent virus	<i>A. caudatus</i> (<i>A. cruentus</i>)
<i>Humulus japonicus</i> virus	<i>A. caudatus</i> (<i>A. cruentus</i>)
<i>Hydrangea</i> ringspot virus	<i>A. caudatus</i> (<i>A. cruentus</i>) <i>A. retroflexus</i>
<i>Iris fulva</i> mosaic virus	<i>A. caudatus</i> (<i>A. cruentus</i>)
<i>Iris</i> mild mosaic virus	<i>A. caudatus</i> (<i>A. cruentus</i>)
<i>Iris</i> ringspot virus	<i>A. retroflexus</i>
Ivy vein clearing virus	<i>A. spp.</i>
<i>Lamium</i> mild mosaic virus ⁴	<i>A. caudatus</i> (<i>A. cruentus</i>)
Large nettle yellow mottle virus	<i>A. retroflexus</i>
Lettuce mosaic virus	<i>A. caudatus</i> (<i>A. cruentus</i>)
Lettuce speckles virus ⁵	<i>A. hybridus</i>
Lilac chlorotic leafspot virus	<i>A. retroflexus</i>
Maracuja (<i>Passiflora edulis</i>) mosaic virus	<i>A. edulis</i>
<i>Narcissus</i> mosaic virus	<i>A. caudatus</i> (<i>A. cruentus</i>)
<i>Narcissus</i> tip necrosis virus	<i>A. caudatus</i> (<i>A. cruentus</i>)
Okra mosaic virus	<i>A. caudatus</i> (<i>A. cruentus</i>) <i>A. retroflexus</i>
Papaya ringspot virus	<i>A. dubius</i>
Pea common mosaic virus	<i>A. caudatus</i> (<i>A. cruentus</i>)
Pea early browning virus	<i>A. caudatus</i> (<i>A. cruentus</i>)
Pea mosaic virus	<i>A. caudatus</i> (<i>A. cruentus</i>)
Peanut stunt virus	<i>A. caudatus</i> (<i>A. cruentus</i>)
<i>Pelargonium</i> leaf curl virus	<i>A. caudatus</i> (<i>A. cruentus</i>)
Pepper veinal mottle virus	<i>A. caudatus</i> <i>A. retroflexus</i>
<i>Physalis</i> shoestring mosaic virus ⁶	<i>A. spp.</i>
Pingweed mosaic virus	<i>A. blitum</i> (syn.: <i>A. ascendens</i>) <i>A. caudatus</i> (<i>A. cruentus</i>) <i>A. cruentus</i> (syn.: <i>A. caudatus</i>) <i>A. dubius</i> <i>A. gangeticus</i> (syn.: <i>A. tricolor</i>) <i>A. leucocarpus</i> <i>A. mangostanus</i> <i>A. spinosus</i> <i>A. viridis</i>
Plantain virus X	<i>A. caudatus</i> (<i>A. cruentus</i>)
<i>Plantago</i> severe mottle virus	<i>A. retroflexus</i>
Plum line pattern virus	<i>A. aurora</i> <i>A. graecizans</i> (syn.: <i>A. angustifolius</i>)
Potato aucuba mosaic virus	<i>A. gangeticus</i> (syn.: <i>A. tricolor</i>) <i>A. retroflexus</i>
Potato black ringspot virus	<i>A. caudatus</i> (<i>A. cruentus</i>)

Table 3 (continued)

Viruses*	<i>Amaranthus</i> hosts
Potato leafroll virus	<i>A. caudatus</i> (<i>A. cruentus</i>) <i>A. graecizans</i> (syn.: <i>A. angustifolius</i>) <i>A. retroflexus</i>
Potato virus M	<i>A. ascendens</i> (syn.: <i>A. blitum</i>) <i>A. atropurpureus</i> <i>A. bouchonii</i> <i>A. caracu</i> <i>A. caudatus</i> cv. <i>Atropurpureus</i> <i>A. chlorostachys</i> f. <i>strictus</i> <i>A. cruentus</i> (syn.: <i>A. caudatus</i>) <i>A. dubius</i> <i>A. gangeticus</i> var. <i>multicolor</i> hort. <i>A. hypochondriacus</i> <i>A. hypochondriacus</i> cv. <i>Monstrosus</i> <i>A. leucocarpus</i> <i>A. mantegazzianus</i> <i>A. oleraceus</i> <i>A. paniculatus</i> <i>A. paniculatus</i> var. <i>flavus</i> <i>A. paniculatus</i> cv. <i>Roter Dom</i> <i>A. retroflexus</i> <i>A. speciosus</i> <i>A. spinosus</i> <i>A. sylvestris</i> <i>A. tricolor</i> (syn.: <i>A. gangeticus</i>) <i>A. viridis</i>
Potato virus N ⁷	<i>A. caudatus</i> (<i>A. cruentus</i>)
Potato virus X	<i>A. angustifolius</i> (syn.: <i>A. graecizans</i>) <i>A. ascendens</i> (syn.: <i>A. blitum</i>) <i>A. atropurpureus</i> <i>A. aureus</i> <i>A. blitum</i> (syn.: <i>A. ascendens</i>) <i>A. bouchonii</i> <i>A. caracu</i> <i>A. caudatus</i> (<i>A. cruentus</i>) <i>A. caudatus</i> cv. <i>Atropurpureus</i> <i>A. chlorostachys</i> <i>A. chlorostachys</i> var. <i>powellii</i> <i>A. cruentus</i> (syn.: <i>A. caudatus</i>) <i>A. deflexus</i> <i>A. dubius</i> <i>A. edulis</i> <i>A. emarginatus</i> <i>A. gangeticus</i> (syn.: <i>A. tricolor</i>) <i>A. gangeticus</i> var. <i>multicolor</i> hort. <i>A. graecizans</i> (syn.: <i>A. angustifolius</i>) <i>A. hybridus</i> <i>A. hypochondriacus</i> <i>A. hypochondriacus</i> cv. <i>Monstrosus</i> <i>A. leucocarpus</i>

Table 3 (continued)

Viruses*	<i>Amaranthus</i> hosts
Potato virus Y	<i>A. lividus</i>
	<i>A. mangostanus</i>
	<i>A. mantegazzianus</i>
	<i>A. mitchellii</i>
	<i>A. oleraceus</i>
	<i>A. paniculatus</i>
	<i>A. paniculatus</i> var. <i>flavus</i>
	<i>A. paniculatus</i> cv. <i>Roter Dom</i>
	<i>A. paniculatus</i> cv. <i>Roter Paris</i>
	<i>A. paniculatus</i> cv. <i>Sanguineus nanus</i>
	<i>A. patulus</i>
	<i>A. quitensis</i>
	<i>A. retroflexus</i>
	<i>A. speciosus</i>
	<i>A. spinosus</i>
	<i>A. sylvestris</i>
	<i>A. tricolor</i> (syn.: <i>A. gangeticus</i>)
	<i>A. tricolor</i> cv. <i>Malten Fire</i>
	<i>A. viridis</i>
	<i>A. angustifolius</i> (syn.: <i>A. graecizans</i>)
	<i>A. ascendens</i> (syn.: <i>A. blitum</i>)
	<i>A. atropurpureus</i>
	<i>A. aureus</i>
	<i>A. bouchonii</i>
	<i>A. caracu</i>
	<i>A. caudatus</i> (<i>A. cruentus</i>)
	<i>A. caudatus</i> cv. <i>Atropurpureus</i>
	<i>A. cruentus</i> (syn.: <i>A. caudatus</i>)
	<i>A. deflexus</i> var. <i>rufescens</i>
	<i>A. dubius</i>
	<i>A. gangeticus</i> var. <i>multicolor</i> hort.
	<i>A. graecizans</i> (syn.: <i>A. angustifolius</i>)
	<i>A. hypochondriacus</i>
	<i>A. hypochondriacus</i> cv. <i>Monstrosus</i>
	<i>A. leucocarpus</i>
	<i>A. lividus</i>
	<i>A. mangostanus</i>
	<i>A. mantegazzianus</i>
	<i>A. mitchellii</i>
	<i>A. oleraceus</i>
	<i>A. paniculatus</i>
	<i>A. paniculatus</i> var. <i>flavus</i>
	<i>A. paniculatus</i> cv. <i>Roter Dom</i>
	<i>A. paniculatus</i> cv. <i>Roter Paris</i>
	<i>A. paniculatus</i> cv. <i>Sanguineus nanus</i>
	<i>A. patulus</i>
	<i>A. quitensis</i>
	<i>A. speciosus</i>
	<i>A. spinosus</i>
	<i>A. sylvestris</i>

Table 3 (continued)

Viruses*	<i>Amaranthus</i> hosts
	<i>A. tricolor</i> (syn.: <i>A. gangeticus</i>)
	<i>A. tricolor</i> cv. <i>Malten Fire</i>
	<i>A. viridis</i>
<i>Prunus</i> necrotic ringspot virus	<i>A. retroflexus</i>
Raspberry bushy dwarf virus	<i>A. caudatus</i> (<i>A. cruentus</i>)
Raspberry ringspot virus	<i>A. hybridus</i> var. <i>hypochondriacus</i>
Red clover necrotic mosaic virus	<i>A. caudatus</i> (<i>A. cruentus</i>)
Red clover vein mosaic virus	<i>A. caudatus</i> (<i>A. cruentus</i>)
Red currant ringspot virus ⁸	<i>A. tricolor</i>
<i>Robinia</i> mosaic virus	<i>A. caudatus</i> (<i>A. cruentus</i>)
Spinach latent virus	<i>A. retroflexus</i>
	<i>A. tricolor</i> (syn.: <i>A. gangeticus</i>)
Sowbane mosaic virus	<i>A. caudatus</i> (<i>A. cruentus</i>)
Strawberry latent ringspot virus	<i>A. albus</i>
	<i>A. caudatus</i> (<i>A. cruentus</i>)
	<i>A. lividus</i>
	<i>A. retroflexus</i>
Tobacco broad ringspot virus ⁹	<i>A. paniculatus</i>
	<i>A. retroflexus</i>
	<i>A. spinosus</i>
Tobacco bushy-top virus ¹¹	<i>A. caudatus</i> (<i>A. cruentus</i>)
Tobacco etch virus	<i>A. angustifolius</i> (syn.: <i>A. graecizans</i>)
Tobacco mosaic virus	<i>A. ascendens</i> (syn.: <i>A. blitum</i>)
	<i>A. atropurpureus</i>
	<i>A. aureus</i>
	<i>A. blitum</i> (syn.: <i>A. ascendens</i>)
	<i>A. bouchonii</i>
	<i>A. caracu</i>
	<i>A. caudatus</i> (<i>A. cruentus</i>)
	<i>A. caudatus</i> cv. <i>Atropurpureus</i>
	<i>A. chlorostachys</i>
	<i>A. chlorostachys</i> f. <i>strictus</i>
	<i>A. chlorostachys</i> var. <i>powellii</i>
	<i>A. cruentus</i> (syn.: <i>A. caudatus</i>)
	<i>A. deflexus</i>
	<i>A. deflexus</i> var. <i>rufescens</i>
	<i>A. dubius</i>
	<i>A. emarginatus</i>
	<i>A. gangeticus</i> var. <i>multicolor</i> hort.
	<i>A. graecizans</i>
	<i>A. hybridus</i>
	<i>A. hypochondriacus</i>
	<i>A. hypochondriacus</i> cv. <i>Monstrosus</i>
	<i>A. lividus</i>
	<i>A. paniculatus</i>
	<i>A. paniculatus</i> var. <i>flavus</i>
	<i>A. paniculatus</i> cv. <i>Roter Dom</i>
	<i>A. paniculatus</i> cv. <i>Roter Paris</i>
	<i>A. paniculatus</i> cv. <i>Sanquineus nanus</i>
	<i>A. retroflexus</i>

Table 3 (continued)

Viruses*	<i>Amaranthus</i> hosts
	<i>A. speciosus</i>
	<i>A. spinosus</i>
	<i>A. sylvestris</i>
	<i>A. tricolor</i> (syn.: <i>A. gangeticus</i>)
	<i>A. tricolor</i> cv. Malten Fire
	<i>A. viridis</i>
Tobacco necrosis virus	<i>A. caudatus</i> (<i>A. cruentus</i>)
	<i>A. paniculatus</i>
Tobacco rattle virus	<i>A. bouchonii</i>
	<i>A. caudatus</i> (<i>A. cruentus</i>)
	<i>A. mangostanus</i>
	<i>A. mitchellii</i>
	<i>A. powellii</i>
	<i>A. quitensis</i>
	<i>A. retroflexus</i>
Tobacco ringspot virus	<i>A. bouchonii</i>
	<i>A. caudatus</i> (<i>A. cruentus</i>)
	<i>A. gangeticus</i> (syn.: <i>A. tricolor</i>)
	<i>A. hybridus</i>
	<i>A. mangostanus</i>
	<i>A. mitchellii</i>
	<i>A. palmeri</i>
	<i>A. paniculatus</i>
	<i>A. quitensis</i>
	<i>A. retroflexus</i>
	<i>A. tricolor</i> (syn.: <i>A. gangeticus</i>)
	<i>A. tricolor</i> cv. Malten Fire
Tobacco streak virus	<i>A. spp.</i>
Tobacco stunt virus	<i>A. paniculatus</i>
Tomato aspermy virus	<i>A. bouchonii</i>
	<i>A. caudatus</i> (<i>A. cruentus</i>)
	<i>A. mangostanus</i>
	<i>A. mitchellii</i>
	<i>A. quitensis</i>
Tomato black ring virus	<i>A. caracu</i>
	<i>A. caudatus</i> (<i>A. cruentus</i>)
	<i>A. graecizans</i>
	<i>A. paniculatus</i>
	<i>A. retroflexus</i>
Tomato bushy stunt virus	<i>A. caudatus</i> (<i>A. cruentus</i>)
Tomato mosaic virus	<i>A. bouchonii</i>
	<i>A. mangostanus</i>
	<i>A. mitchellii</i>
	<i>A. quitensis</i>
Tomato ringspot virus	<i>A. retroflexus</i>
	<i>A. tricolor</i> (syn.: <i>A. gangeticus</i>)
Tomato spotted wilt virus	<i>Amaranthus</i> sp.
	<i>A. caudatus</i> (<i>A. cruentus</i>)
	<i>A. graecizans</i>
	<i>A. hybridus</i>

Table 3 (continued)

Viruses*	<i>Amaranthus</i> hosts
	<i>A. retroflexus</i>
	<i>A. viridis</i>
<i>Tropaeolum</i> mosaic virus ¹	<i>A. caudatus</i> (<i>A. cruentus</i>)
Turnip crinkle virus	<i>A. caudatus</i> (<i>A. cruentus</i>)
Turnip mosaic virus	<i>A. ascendens</i> (syn.: <i>A. blitum</i>)
	<i>A. caudatus</i> (<i>A. cruentus</i>)
	<i>A. paniculatus</i>
	<i>A. retroflexus</i>
	<i>A. tricolor</i> (syn.: <i>A. gangeticus</i>)
UV ¹	<i>A. deflexus</i>
UV-potexvirus ¹	<i>A. caudatus</i> (<i>A. cruentus</i>)
UV ^{1,5}	<i>A. quitensis</i>
<i>Viola</i> mottle virus	<i>A. caudatus</i> (<i>A. cruentus</i>)
	<i>A. hybridus</i>
Watermelon mosaic virus (strain 2)	<i>A. caudatus</i> (<i>A. cruentus</i>)
	<i>A. lividus</i>
White clover virus	<i>A. caudatus</i> (<i>A. cruentus</i>)
<i>Wisteria</i> vein mosaic virus	<i>A. hybridus</i>
Zucchini yellow mosaic virus	<i>A. bouchonii</i>
	<i>A. mangostanus</i>
	<i>A. mitchellii</i>
	<i>A. quitensis</i>

* See the explanation at the end of the Table 1.

Table 4

Susceptible *Amaranthus* species in different virus groups

Virus group	Number of viruses (Members of group)*	<i>Amaranthus</i> species
Alfalfa mosaic virus (group)	1 (1)	<i>Amaranthus albus</i> <i>A. angustifolius</i> (syn.: <i>A. graecizans</i>) <i>A. ascendens</i> (syn.: <i>A. blitum</i>) <i>A. atropurpureus</i> <i>A. aureus</i> <i>A. blitoides</i> <i>A. bouchonii</i> <i>A. caracu</i> <i>A. caudatus</i> (<i>A. cruentus</i>) <i>A. caudatus</i> cv. <i>Atropurpureus</i> <i>A. chlorostachys</i> <i>A. chlorostachys</i> f. <i>strictus</i> <i>A. chlorostachys</i> var. <i>powellii</i> <i>A. cruentus</i> (syn.: <i>A. caudatus</i>) <i>A. dubius</i> <i>A. emarginatus</i> <i>A. gangeticus</i> var. <i>multicolor</i> hort. <i>A. graecizans</i> (syn.: <i>A. angustifolius</i>) <i>A. hybridus</i> <i>A. hybridus</i> ssp. <i>incurvatus</i> <i>A. hypochondriacus</i> <i>A. hypochondriacus</i> cv. <i>Monstrosus</i> <i>A. leucocarpus</i> <i>A. lividus</i> <i>A. mantegazzianus</i> <i>A. oleraceus</i> <i>A. paniculatus</i> <i>A. paniculatus</i> var. <i>flavus</i> <i>A. paniculatus</i> cv. <i>Roter Dom</i> <i>A. paniculatus</i> cv. <i>Roter Paris</i> <i>A. paniculatus</i> cv. <i>Sanquineus nanus</i> <i>A. patulus</i> <i>A. retroflexus</i> <i>A. speciosus</i> <i>A. spinosus</i> <i>A. sylvestris</i> <i>A. tricolor</i> (syn.: <i>A. gangeticus</i>) <i>A. tricolor</i> cv. <i>Malten Fire</i> <i>A. viridis</i>
Apple stem grooving virus (group)	1 (1)	<i>A. retroflexus</i> <i>A. tricolor</i> (syn.: <i>A. gangeticus</i>)
Carlavirus	4 (14a, 44, 80, 88)	<i>A. ascendens</i> (syn.: <i>A. blitum</i>) <i>A. atropurpureus</i> <i>A. bouchonii</i> <i>A. caracu</i> <i>A. caudatus</i> (<i>A. cruentus</i>) <i>A. caudatus</i> cv. <i>Atropurpureus</i> <i>A. chlorostachys</i> f. <i>strictus</i>

Table 4 (continued)

Virus group	Number of viruses (Members of group)	<i>Amaranthus</i> species
		<i>A. cruentus</i> (syn.: <i>A. caudatus</i>) <i>A. dubius</i> <i>A. gangeticus</i> var. <i>multicolor</i> hort. <i>A. hypochondriacus</i> <i>A. hypochondriacus</i> cv. <i>Monstrosus</i> <i>A. leucocarpus</i> <i>A. mantegazziaunus</i> <i>A. oleraceus</i> <i>A. paniculatus</i> <i>A. paniculatus</i> var. <i>flavus</i> <i>A. paniculatus</i> cv. <i>Roter Dom</i> <i>A. retroflexus</i> <i>A. speciosus</i> <i>A. spinosus</i> <i>A. sylvestris</i> <i>A. tricolor</i> (syn.: <i>A. gangeticus</i>) <i>A. viridis</i>
Caulimovirus	1 (42)	<i>A. caudatus</i> (<i>A. cruentus</i>)
Closterovirus	3 (23, 48, 60)	<i>A. albus</i> <i>A. aspera</i> <i>A. aureus</i> <i>A. caracu</i> <i>A. carneus</i> <i>A. caudatus</i> (<i>A. cruentus</i>) <i>A. cruentus</i> (syn.: <i>A. caudatus</i>) <i>A. cruentus</i> (syn.: <i>A. caudatus</i>) <i>A. deflexus</i> <i>A. gangeticus</i> (syn.: <i>A. tricolor</i>) <i>A. graecizans</i> (syn.: <i>A. angustifolius</i>) <i>A. lividus</i> <i>A. palmeri</i> <i>A. paniculatus</i> <i>A. patulus</i> <i>A. retroflexus</i> <i>A. speciosus</i>
Comovirus	1 (39)	<i>A. caudatus</i> (<i>A. cruentus</i>)
Cucumovirus	5 (40, 69, 81, 90, 103)	<i>A. angustifolius</i> (<i>A. graecizans</i>) <i>A. ascendens</i> (syn.: <i>A. blitum</i>) <i>A. atropurpureus</i> <i>A. aureus</i> <i>A. blitum</i> (syn.: <i>A. ascendens</i>) <i>A. bouchonii</i> <i>A. caracu</i> <i>A. caudatus</i> (<i>A. cruentus</i>) <i>A. caudatus</i> cv. <i>Atropurpureus</i> <i>A. chlorostachys</i> <i>A. chlorostachys</i> f. <i>strictus</i> <i>A. chlorostachys</i> var. <i>powellii</i> <i>A. cruentus</i> (syn.: <i>A. caudatus</i>) <i>A. deflexus</i>

Table 4 (continued)

Virus group	Number of viruses (Members of group)	<i>Amaranthus</i> species
		<i>A. dubius</i> <i>A. emarginatus</i> <i>A. gangeticus</i> (syn.: <i>A. tricolor</i>) <i>A. gangeticus</i> var. <i>multicolor</i> hort. <i>A. graecizans</i> (syn.: <i>A. angustifolius</i>) <i>A. hybridus</i> <i>A. hypochondriacus</i> <i>A. hypochondriacus</i> cv. <i>Monstrosus</i> <i>A. leucocarpus</i> <i>A. lividus</i> <i>A. mangostanus</i> <i>A. mantegazzianus</i> <i>A. mitchellii</i> <i>A. oleraceus</i> <i>A. paniculatus</i> <i>A. paniculatus</i> var. <i>flavus</i> <i>A. paniculatus</i> cv. <i>Roter Dom</i> <i>A. paniculatus</i> cv. <i>Roter Paris</i> <i>A. paniculatus</i> cv. <i>Sanquineus nanus</i> <i>A. patulus</i> <i>A. quitensis</i> <i>A. retroflexus</i> <i>A. speciosus</i> <i>A. spinosus</i> <i>A. sylvestris</i> <i>A. tricolor</i> (syn.: <i>A. gangeticus</i>) <i>A. tricolor</i> cv. <i>Malten Fire</i> <i>A. viridis</i>
Dianthovirus	2 (31, 87)	<i>A. caudatus</i> (<i>A. cruentus</i>) <i>A. hybridus</i> <i>A. paniculatus</i>
Furovirus	1 (21)	<i>A. retroflexus</i> <i>A. bouchonii</i>
Geminivirus	1 (19)	<i>A. mangostanus</i> <i>A. caudatus</i> (<i>A. cruentus</i>) <i>A. deflexus</i> <i>A. gangeticus</i> (syn.: <i>A. tricolor</i>) <i>A. graecizans</i> (syn.: <i>A. angustifolius</i>) <i>A. retroflexus</i>
Hordeivirus	1 (17)	<i>A. retroflexus</i>
Ilarvirus	7 (16, 45, 49, 76, 84, 91, 101)	<i>A. spp.</i> <i>A. aurora</i> <i>A. caudatus</i> (<i>A. cruentus</i>) <i>A. graecizans</i> (syn.: <i>A. angustifolius</i>) <i>A. retroflexus</i> <i>A. tricolor</i> (syn.: <i>A. gangeticus</i>)
Luteovirus	2 (22, 79)	<i>A. caudatus</i> (<i>A. cruentus</i>) <i>A. graecizans</i> (syn.: <i>A. angustifolius</i>) <i>A. retroflexus</i>
Necrovirus	1 (98)	<i>A. caudatus</i> (<i>A. cruentus</i>)

Table 4 (continued)

Virus group	Number of viruses (Members of group)	<i>Amaranthus</i> species
Nepovirus	15 (11, 12, 13, 14, 15, 34, 42a, 46, 78, 86, 89, 93, 100, 104, 106a)	<i>A. paniculatus</i>
		<i>A. albus</i>
		<i>A. bouchonii</i>
		<i>A. caracu</i>
		<i>A. caudatus</i> (<i>A. cruentus</i>)
		<i>A. edulis</i>
		<i>A. gangeticus</i> (syn.: <i>A. tricolor</i>)
		<i>A. hybridus</i>
		<i>A. hybridus</i> var. <i>hypochondriacus</i>
		<i>A. lividus</i>
		<i>A. mangostanus</i>
		<i>A. mitchellii</i>
		<i>A. palmeri</i>
		<i>A. paniculatus</i>
		<i>A. patulus</i>
		<i>A. quitensis</i>
		<i>A. retroflexus</i>
		<i>A. tricolor</i> (syn.: <i>A. gangeticus</i>)
		<i>A. tricolor</i> cv. <i>Malten Fire</i>
Potexvirus	11 (28, 36, 50, 62, 74, 75, 77, 82, 112, 114, 116)	<i>A. angustifolius</i> (syn.: <i>A. graecizans</i>)
		<i>A. ascendens</i> (syn.: <i>A. blitum</i>)
		<i>A. atropurpureus</i>
		<i>A. aureus</i>
		<i>A. blitum</i> (syn.: <i>A. ascendens</i>)
		<i>A. bouchonii</i>
		<i>A. caracu</i>
		<i>A. caudatus</i> (<i>A. cruentus</i>)
		<i>A. caudatus</i> cv. <i>Atropurpureus</i>
		<i>A. chlorostachys</i>
		<i>A. chlorostachys</i> var. <i>powellii</i>
		<i>A. cruentus</i> (syn.: <i>A. caudatus</i>)
		<i>A. deflexus</i>
		<i>A. dubius</i>
		<i>A. edulis</i>
		<i>A. emarginatus</i>
		<i>A. gangeticus</i> (syn.: <i>A. tricolor</i>)
		<i>A. gangeticus</i> var. <i>multicolor</i> hort.
		<i>A. graecizans</i> (syn.: <i>A. angustifolius</i>)
		<i>A. hybridus</i>
		<i>A. hypochondriacus</i>
		<i>A. hypochondriacus</i> cv. <i>Monstrosus</i>
		<i>A. leucocarpus</i>
		<i>A. lividus</i>
		<i>A. mangostanus</i>
		<i>A. mantegazzianus</i>
		<i>A. mitchellii</i>
		<i>A. oleraceus</i>
		<i>A. paniculatus</i>
		<i>A. paniculatus</i> var. <i>cruentus</i>
		<i>A. paniculatus</i> var. <i>flavescens</i>

Table 4 (continued)

Virus group	Number of viruses (Members of group)	Amaranthus species
Potyvirus	24 (2, 5, 18, 20, 27, 32, 37, 38, 47, 51, 52, 53, 58, 65, 66, 68, 71, 73, 83, 96, 110, 115, 117, 118)	<i>A. paniculatus</i> cv. <i>Roter Dom</i> <i>A. paniculatus</i> cv. <i>Roter Paris</i> <i>A. paniculatus</i> cv. <i>Saquineus nanus</i> <i>A. patulus</i> <i>A. quitensis</i> <i>A. retroflexus</i> <i>A. silvester</i> <i>A. speciosus</i> <i>A. spinosus</i> <i>A. sylvestris</i> <i>A. tricolor</i> (syn.: <i>A. gangeticus</i>) <i>A. tricolor</i> cv. <i>Malten Fire</i> <i>A. viridis</i> <i>A. albus</i> <i>A. albus</i> var. <i>roseus</i> <i>A. angustifolius</i> (syn.: <i>A. graecizans</i>) <i>A. ascendens</i> (syn.: <i>A. blitum</i>) <i>A. atropurpureus</i> <i>A. aureus</i> <i>A. blitum</i> (syn.: <i>A. ascendens</i>) <i>A. bouchonii</i> <i>A. caracu</i> <i>A. caudatus</i> (<i>A. cruentus</i>) <i>A. caudatus</i> cv. <i>Atropurpureus</i> <i>A. cruentus</i> (syn.: <i>A. caudatus</i>) <i>A. deflexus</i> <i>A. deflexus</i> var. <i>rufescens</i> <i>A. dubius</i> <i>A. gangeticus</i> (syn.: <i>A. tricolor</i>) <i>A. gangeticus</i> var. <i>multicolor</i> <i>A. graecizans</i> (syn.: <i>A. angustifolius</i>) <i>A. hybridus</i> <i>A. hypochondriacus</i> <i>A. hypochondriacus</i> cv. <i>Monstrosus</i> <i>A. leucocarpus</i> <i>A. lividus</i> <i>A. mangostanus</i> <i>A. mantegazzianus</i> <i>A. mitchellii</i> <i>A. monstrosus</i> <i>A. oleraceus</i> <i>A. paniculatus</i> <i>A. paniculatus</i> var. <i>flavus</i> <i>A. paniculatus</i> cv. <i>Roter Dom</i> <i>A. paniculatus</i> cv. <i>Roter Paris</i> <i>A. paniculatus</i> cv. <i>Sanquineus nanus</i> <i>A. patulus</i> <i>A. quitensis</i> <i>A. retroflexus</i> <i>A. speciosus</i>

Table 4 (continued)

Virus group	Number of viruses (Members of group)	<i>Amaranthus</i> species
		<i>A. spinosus</i>
		<i>A. sylvestris</i>
		<i>A. tricolor</i> (syn.: <i>A. gangeticus</i>)
		<i>A. tricolor</i> cv. Malten Fire
		<i>A. viridis</i>
Rhabdovirus	1 (55)	<i>A. spp.</i>
Sobemovirus	1 (92)	<i>A. caudatus</i> (<i>A. cruentus</i>)
Tobamovirus	4 (61, 72, 97, 106)	<i>A. spp.</i>
		<i>A. angustifolius</i> (syn.: <i>A. graecizans</i>)
		<i>A. ascendens</i> (syn.: <i>A. blitum</i>)
		<i>A. atropurpureus</i>
		<i>A. aureus</i>
		<i>A. blitum</i> (syn.: <i>A. ascendens</i>)
		<i>A. bouchonii</i>
		<i>A. caracu</i>
		<i>A. caudatus</i> (<i>A. cruentus</i>)
		<i>A. caudatus</i> cv. <i>Atropurpureus</i>
		<i>A. chlorostachys</i>
		<i>A. chlorostachys</i> var. <i>powellii</i>
		<i>A. cruentus</i> (syn.: <i>A. caudatus</i>)
		<i>A. deflexus</i>
		<i>A. deflexus</i> var. <i>rufescens</i>
		<i>A. dubius</i>
		<i>A. edulis</i>
		<i>A. emarginatus</i>
		<i>A. gangeticus</i> var. <i>multicolor</i> hort.
		<i>A. graecizans</i> (syn.: <i>A. angustifolius</i>)
		<i>A. hybridus</i>
		<i>A. hypochondriacus</i>
		<i>A. hypochondriacus</i> cv. <i>Monstrosus</i>
		<i>A. lividus</i>
		<i>A. mangostanus</i>
		<i>A. mitchellii</i>
		<i>A. paniculatus</i>
		<i>A. paniculatus</i> var. <i>flavus</i>
		<i>A. paniculatus</i> cv. <i>Roter Dom</i>
		<i>A. paniculatus</i> cv. <i>Roter Paris</i>
		<i>A. paniculatus</i> cv. <i>Sanquineus nanus</i>
		<i>A. quitensis</i>
		<i>A. retroflexus</i>
		<i>A. speciosus</i>
		<i>A. spinosus</i>
		<i>A. sylvestris</i>
		<i>A. tricolor</i> (syn.: <i>A. gangeticus</i>)
		<i>A. tricolor</i> cv. Malten Fire
		<i>A. viridis</i>
Tobravirus	2 (67, 99)	<i>A. bouchonii</i>
		<i>A. caudatus</i> (<i>A. cruentus</i>)
		<i>A. mangostanus</i>
		<i>A. mitchellii</i>

Table 4 (continued)

Virus group	Number of viruses (Members of group)	<i>Amaranthus</i> species
Tospovirus	1 (107)	<i>A. powellii</i>
		<i>A. quitensis</i>
		<i>A. retroflexus</i>
		<i>A. caudatus</i> (<i>A. cruentus</i>)
		<i>A. graecizans</i> (syn.: <i>A. angustifolius</i>)
		<i>A. hybridus</i>
Tombusvirus	8 (29, 30, 41, 43, 63, 70, 105, 109)	<i>A. retroflexus</i>
		<i>A. viridis</i>
		<i>A. caudatus</i> (<i>A. cruentus</i>)
		<i>A. hybridus</i>
		<i>A. paniculatus</i>
Tymovirus	3 (7, 24, 64)	<i>A. retroflexus</i>
		<i>A. viridis</i>
		<i>A. bouchonii</i>
		<i>A. caudatus</i> (<i>A. cruentus</i>)
		<i>A. edulis</i>
		<i>A. mangostanus</i>
Ungrouped or unidentified (unclassified) viruses	18 (3, 4, 5, 6, 9, 25, 26, 33, 35, 54, 56, 57, 59, 85, 94, 102, 108, 111)	<i>A. mitchellii</i>
		<i>A. quitensis</i>
		<i>A. retroflexus</i>
		<i>A. spp.</i>
		<i>A. albus</i>
		<i>A. blitum</i> (syn.: <i>A. ascendens</i>)
		<i>A. bouchonii</i>
		<i>A. caudatus</i> (<i>A. cruentus</i>)
		<i>A. cruentus</i> (syn.: <i>A. caudatus</i>)
		<i>A. deflexus</i>
		<i>A. flavus</i>
		<i>A. gangeticus</i> (syn.: <i>A. tricolor</i>)
		<i>A. gracilis</i>
		<i>A. hybridus</i>
		<i>A. hybridus</i> var. <i>hypochondriacus</i>
		<i>A. leucocarpus</i>
		<i>A. lividus</i>
		<i>A. lividus</i> var. <i>ascendens</i>
		<i>A. mangostanus</i>
Komplex or mixed virus	1 (95)	<i>A. mitchellii</i>
		<i>A. paniculatus</i>
		<i>A. quitensis</i>
		<i>A. retroflexus</i>
		<i>A. viridis</i>
		<i>A. spinosus</i>

Table 4 (continued)

*Key: 1 – Alfalfa mosaic, 2 – *Amaranthus* leaf mottle, 3 – *Amaranthus lividus*, 4 – *Amaranthus lividus* mottle, 5 – *Amaranthus* mosaic, 6 – *Amaranthus* mottle, 7 – Andean potato latent, 8 – *Anemone* brown ring, 9 – *Anemone* mosaic, 10 – Apple stem grooving, 11 – *Arabis* mosaic, 12 – *Arracacha* A, 13 – *Arracacha* B, 14 – Artichoke Italian latent, 14a – Artichoke latent, 15 – Artichoke yellow ringspot, 16 – *Asparagus* 2, 17 – Barley stripe mosaic, 18 – Bean yellow mosaic, 19 – Beet curly top, 20 – Beet mosaic, 21 – Beet necrotic yellow vein, 22 – Beet western yellows, 23 – Beet yellows, 24 – Belladonna mottle, 25 – Black locust true, 26 – Broad bean wilt, 27 – Cabbage black ring, 28 – *Cactus* X, 29 – Carnation Italian, ringspot, 30 – Carnation mottle, 31 – Carnation ringspot, 32 – Carnation vein mottle, 33 – Celery latent, 34 – Celery yellow vein, 35 – *Chrysanthemum* latent, 36 – Clover yellow mosaic, 37 – Clover yellow vein, 38 – Cowpea aphid-borne mosaic, 39 – Cowpea mosaic, 40 – Cucumber mosaic, 41 – *Cymbidium* ringspot, 42 – *Dahlia* mosaic, 42a – Dogwood mosaic virus, 43 – Eggplant mottled crinkle, 44 – Elderberry carla, 45 – Elm mottle, 46 – Grapevine fanleaf, 47 – Henbane mosaic, 48 – *Heracleum* latent, 49 – *Humulus japonicus*, 50 – *Hydrangea* ringspot, 51 – *Iris fulva* mosaic, 52 – *Iris* mild mosaic, 53 – *Iris* mosaic, 54 – *Iris* rings pot, 55 – Ivy vein clearing, 56 – *Lamium* mild mosaic, 57 – Large nettle yellow mottle, 58 – Lettuce mosaic, 59 – Lettuce speckles, 60 – Lilac chlorotic leafspot, 61 – Maracuja (*Passiflora edulis*) mosaic, 62 – *Narcissus* mosaic, 63 – *Narcissus* tip necrosis, 64 – Okra mosaic, 65 – Papaya ringspot, 66 – Pea common mosaic, 67 – Pea early browning, 68 – Pea mosaic, 69 – Peanut stunt, 70 – *Pelargonium* leaf curl, 71 – Pepper veinal mottle, 72 – *Physalis* shoestring mosaic, 73 – Pingweed mosaic, 74 – Plantain X, 75 – *Plantago* severe mottle, 76 – Plum line pattern, 77 – Potato aucuba mosaic, 78 – Potato balck ringspot, 79 – Potato leafroll, 80 – Potato M, 81 – Potato N, 82 – Potato X, 83 – Potato Y, 84 – *Prunus* necrotic ringspot, 85 – Raspberry bushy dwarf, 86 – Raspberry ringspot, 87 – Red clover necrotic mosaic, 88 – Red clover vein mosaic, 89 – Red currant ringspot, 90 – *Robinia* mosaic, 91 – Spinach latent, 92 – Sowbane mosaic, 93 – Strawberry latent ringspot, 94 – Tobacco broad ringspot, 95 – Tobacco bushy-top, 96 – Tobacco etch, 97 – Tobacco mosaic, 98 – Tobacco necrosis, 99 – Tobacco rattle, 100 – Tobacco ringspot, 101 – Tobacco streak, 102 – Tobacco stunt, 103 – Tomato aspermy, 104 – Tomato black ring, 105 – Tomato bushy stunt, 106 – Tomato mosaic, 106a – Tomato ringspot, 107 – Tomato spotted wilt, 108 – *Tropaeolum* mosaic, 109 – Turnip crinkle, 110 – Turnip mosaic, 111 – unidentified virus-1, 112 – unidentified potex, 113 – unidentified virus-5, 114 – *Viola* mottle, 115 – Watermelon mosaic (strain 2), 116 – White clover, 117 – *Wisteria* vein mosaic, 118 – Zucchini yellow mosaic viruses. More information see in Key of Table 1.

Amaranthus hosts in different virus groups

The 121 viruses infecting *Amaranthus* species belong to 24 virus groups, one “unidentified” and one “complex or mixed” virus group. With the number of susceptible *Amaranthus* species taken into consideration the following order of succession can be established for the virus groups: potexvirus group (44), cucumovirus and potyvirus groups (42 each), tobamovirus group (40), alfalfa mosaic virus group (38). Considering that the virus groups significantly differ in the number of viruses included in them (1-23 in the above virus groups), the relative virus-host index – obtained by dividing the number of susceptible *Amaranthus* species listed for a given virus group by the number of viruses included in it – will be the following: alfalfa mosaic virus group 38, tobamovirus group 10, cucumovirus group 8.4, potexvirus group 4 and potyvirus group 1.8. Major importance would naturally be attached to such a numerical expression of host-virus or virus-host relations only if identical number of viruses were contained in the different virus groups.

In Table 4 only two virus groups (carlavirus group and tobamovirus group) can be found for which *Amaranthus* hosts of equally 4 viruses are listed. If these viruses and the number of their *Amaranthus* hosts are compared, it can be established that the virus-host index is 10 for the tobamoviruses and 6 for the carlaviruses. A further question may be whether in the study of hosts for tobamoviruses and carlaviruses the *Amaranthus* species were uniformly subjects of examinations.

Conclusions

The affinity of *Amaranthus* species to plant viruses is highly remarkable. The cosmopolitan *Amaranthus* species which show an ever wider distribution, together with the various perennial species and the recently appearing *Amaranthus bouchonii* – supposedly introduced from the USA – play an increasing role in the spreading and survival of viruses. These wide and known host-virus relations suggest that the virologically so far unknown *Amaranthus* species – some 40 in number – also have an important part in the distribution and ecology of viruses. A future task of scientific research is to detect these so far unknown host-virus relations.

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