Viruses and Phytoplasma Reported on the Most Important Vegetable Crops in Syria: A Review

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Abstract

Ismaeil, F., J. Mando, M. Alkhalaf and S.G. Kumari. 2023. Viruses and Phytoplasma Reported on the Most Important Vegetable Crops in Syria: A Review. Arab Journal of Plant Protection, 41(4): 444-458.
https://doi.org/10.22268/AJPP-41.4.444458

Syria is famous for cultivation of many different vegetable crops in most governorates during both winter and summer growing seasons, due to its Mediterranean moderate climate conditions, characterized by a mild winter and a hot dry summer. Vegetables cultivation is a very important sector of the Syrian agriculture, as it represents an important source of income for growers and a source of hard currency through export. The most important vegetables cultivated in Syria are solanaceous crops (potato, tomato, sweet potato, pepper and eggplant), cucurbits (watermelon, melon, cucumber, squash and pumpkin), legumes (broad bean, green bean, green pea and cowpea), cruciferaceous (white cabbage and white cauliflower) and other species such as: green onion, green garlic, lettuce, okra … etc. These vegetable crops are affected by many diseases caused by different causal agents, among them, viruses, viroids and phytoplasmas that are considered the most important pathogens causing many serious and significant diseases. In Syria, during the past forty years, many viruses and few phytoplasmas were investigated and most of them (especially viruses) were recorded on these vegetable crops through many field surveys carried out to evaluate their sanitary status and to determine the economic losses and damages caused by those pathogens. Tens of studies were implemented with the aim of identifying those causal agents on the most important vegetable crops grown in the country and finding out the appropriate approaches for their effective control. Many available and appropriate diagnostic methods such as biological, serological and molecular techniques were used to assess the sanitary status of these crops.

Keywords: Diseases, Vegetable crops, Viruses, Phytoplasmas, Syria.

Introduction

In Syria, cultivation of vegetable crops is considered a very important source of income for many farmers and for the country national economy. The moderate Mediterranean climate conditions prevailing in Syria are suitable for growing many vegetables in both winter and summer growing seasons. Vegetables are cultivated in most Syrian governorates, for either local consumption or export. Most of the grown vegetables are used fresh or for industry.

The most important vegetable crops grown in Syria belong to the family *Solanaceae* and genus *Solanum* including potato (*Solanum tuberosum* L.), tomato (*S. lycopersicum* L.), eggplant (*S. melongena* L.), pepper (*Capsicum annum* L.) and sweet potato (*Ipomoea batatas* (L.) Lam.) which belongs to the family *Convulvulaceae*.

According to the most recent agricultural statistics issued by the Ministry of Agriculture and Agrarian Reform, the cultivated area with potato was estimated to be 27,489 hectares with a total annual production of 647.319 tones (Anonymous, 2020). Tomato cultivation area in 2020 reached 14,458 hectares with a total production of 780,617 tons (Anonymous, 2020). Furthermore, in the coastal region (Tartous & Latakia governorates), tomato is widely cultivated under greenhouses, especially in Tartous governorate. The number of greenhouses was estimated to be 97,547 houses with a cultivation area of 3,902 hectares with 487,735 tons of total annual production. The eggplant cultivation area was around 9,456 hectares in 2020 with a total annual production of 180,002 tons and the pepper cultivation area was estimated to be 5,237 hectares with total annual production of 77,705 tons (Anonymous, 2020).

The other important vegetable crops cultivated in Syria belong to the family *Cucurbitaceae*, such as cucumber (*Cucumis sativus* L.), melon (*C. melo* L.), watermelon (*Citrullus lanatus* (Thunb.) Matsum. & Nakai), green squash or zucchini (*Cucurbita pepo* Mill.) and pumpkin (*C. maxima* Duchesne). The cultivation area of cucumber in 2020 was estimated to be 10,888 hectares with annual production of 182,415 tons. The cultivation area of watermelon is estimated around 23,163 hectares with annual production of 328,325 tons and 8.148 hectares of melon cultivation area with 139,074 tons of annual production. Squash cultivation area was around 5,826 hectares with annual production of 107,262 tons and finally the cultivation area of pumpkin was estimated around 2,029 hectares with annual production of 16.856 tons (Anonymous, 2020).

Some of legumes are cultivated and used as fresh green vegetables which belong to the family *Fabaceae*, such as faba bean (*Vicia faba* L.), green bean or dry bean (*Phaseolus vulgaris* L.), green pea (*Pisum sativum* L.) and green kidney or cowpea (*Vigna unquiculata* L.). Cultivation areas of these legumes were estimated around 7,966, 3,877, 1,815 and

https://doi.org/10.22268/AJPP-41.4.444458

1,238 hectares with annual production of 71,010, 36,799, 15,481 and 7,052 tons, respectively (Anonymous, 2020).

Some vegetables are cultivated in winter and belong to the family *Cruciferaceae*, such as white cabbage (*Brassica oleraceae* var. *capitate*) and white cauliflower (*B. oleraceae* var. *botrytis*). The cultivation area of white cabbage in 2020 was around 2,760 hectares with annual production of 58,543 tons, whereas for white cauliflower, the total area was around 2,110 hectares and total production of 36,151 tons (Anonymous, 2020).

Dry onion (*Allium cepa* L.) and dry garlic (*A. sativum* L.), family *Amaryllidaceae* are also cultivated in Syria with cultivation areas in 2020 was around 6,089 and 3,844 hectares with annual production of 76,700 and 29,961 tons, respectively (Anonymous, 2020). Some of the production from both crops are used as fresh green vegetable for local consumption. In addition, many other vegetable crops are cultivated but with less cultivation areas and less economic importance, such as lettuce (*Lactuca sativa* L.), okra (*Abelmoschus esculentus* L. Moench) and many other species.

Generally, vegetable crops are affected by many biotic disease factors such as viruses, viroids and phytoplasmas in addition to fungi, bacteria and nematodes which can cause serious diseases on several vegetable crops. Many viruses, viroids and phytoplasmas were recorded during the last century and until present on different vegetable crops worldwide. This review article focuses on the most important viruses and phytoplasmas previously reported as disease causal agents on different vegetable crops grown in the country over the past four decades.

Viruses of solanaceous crops

Nine viruses were recorded through a general field survey conducted during 2004-2006 in six Syrian governorates on solanaceous crops (potato, tomato, eggplant and pepper). Cucumber mosaic virus (CMV) was the most common virus, followed by Potato virus Y (PVY), Tobacco ring spot virus (TRSV), Tobacco mosaic virus (TMV), Potato virus X (PVX), Beet western yellows virus (BWYV), Tomato spotted wilt virus (TSWV), Tomato black ring virus (ToBRV), and Tobacco rattle virus (TRV). Virus incidence in tested samples infected with single or mixed infections was 22.8 and 42.8%, respectively (Haj Kassem & Refai, 2009).

Potato viruses

The first report of potato viruses in Syria was done by Haj Kassem and his colleagues (Haj Kassem *et al.*, 1997; Haj Kassem & Abdullatif, 1997). They investigated some viruses infecting this crop in Aleppo during 1993-1994 and the following viruses were detected serologically: PVY, PVX, Potato virus A (PVA), Potato virus S (PVS), Potato virus M (PVM) and Potato leaf roll virus (PLRV). Later, many field surveys were conducted to identify the presence of potato viruses. During 2002-2004, PVY, PLRV, PVS and PVX were investigated in Aleppo and only PVY was detected (Chikh Ali *et al.*, 2006). The same result obtained when four potato cultivars were tested for the presence of six viruses. All cultivars were infected only with PVY and its infection rate ranged between 12.5% on Noveta cultivar and 37.5% on Draga cultivar. Transmission rate of the virus was high in Draga (70.37%) and low in Lizita (44.44%) (Ismail *et al.*, 2004a). Another field survey was conducted in Aleppo and Idleb during 2005-2007. Six viruses were detected: PVY (86.5%), PVA (14%), PVS (2%), PVM (1.6%), PVX (0.8%) and PLRV (0.44%) of tested samples (Haj Kassem *et al.*, 2007a). In 2008, PVY, PVS, CMV and PLRV were detected at infection rates of 54.2, 8.4, 3.7 and 0.9%, respectively and the overall infection rate was 72.9% (Chikh Ali *et al.*, 2008). An expanded field survey in six governorates was conducted during 2003-2005. Seven viruses were detected, PVY was the most common virus, followed by PVX, PLRV, CMV, PVS, Alfalfa mosaic virus (AMV), and Potato aucuba mosaic virus (PAMV). Virus infections were with only one virus, two viruses and three viruses or more with 12.8, 23.8 and 39.2%, respectively. That was the first record of CMV, AMV, PAMV on potato in Syria (Haj Kassem *et al.*, 2007b; Haj Kassem & Refai, 2009; 2011). Another survey was carried out in southern Syria during 1996-2000. Eleven viruses were recorded and PVY was the most common virus at 76% of tested samples (Kawas, 2009).

Moreover, in 2013 a survey of PVY on some solanaceous crops and their associated weeds was conducted in Latakia. Overall PVY infection rate was 40.72% and in tested symptomatic samples of solanaceous field crops were 52.63% and 25.09% in weeds, 21.58% in solanaceous greenhouse crops and 27.27% in weeds (Halabi *et al.*, 2015). Furthermore, a field survey was done in Damascus countryside during 2012-2013 to identify the following viruses: PLRV, PVY, PVX, PVS, PVA and PVM. The total infection rate was 81.6% and virus infections were high in Zakia, Beat-Saber and Keswa (92.9%) and Saasaa had the lowest rate (64.2%) of infection. PVY (63.3%), PVX (34.7%) and PLRV (20.4%) were the most prevailing viruses (Hajali *et al.*, 2015). Finally, PVY, CMV, AMV and TSWV were investigated in six governorates during 2008. The overall rates of infection in tested compound samples were 6.4, 3.8, 3.6 and 0.7% for PVY, AMV, CMV and TSWV, respectively (Al-Chaabi *et al.*, 2016).

A study was conducted to determine the effect of the primary infection date with a local isolate of PVY on the yield of three potato cultivars and on PVY-tuber transmission. The lowest PVY-tuber transmission rate was in Burren cultivar, followed by Spunta and the highest in Penilla (Ismail *et al.*, 2007a; 2007b). Likewise, the transmission of PVY through tubers of two potato cultivars during 2009-2010 were tested. Transmission rates ranged between 75% in the big size of Spunta and 4.7% in the medium size of Marfona. Generally, the transmission rate was higher in Spunta cultivar than in Marfona (Mobayed *et al.*, 2012).

In 2007, an antiserum against a local PVY isolate was produced for the first time. This antiserum gave consistent results and was highly specific with undetectable cross reaction with plant proteins. It was very sensitive, and the virus could be detected in highly diluted plant sap (Sankari *et al.*, 2007).

PVY was the most studied virus in Syria and many studies aimed to characterize its strains. PVY^{N}, PVY^{C} and $PVY^{C/O}$ strains were surveyed in Latakia, with 77.5% of them reacted positively with PVY monoclonal antibodies

(MAbs). Single infection with one strain was detected at different rates, 48.6% for PVY^{N} and 35.1% for PVY^{O}. Mixed infections were also detected and no single infection with PVY^{C} was found (Ismail & Ra`ai, 2004). Another field survey of PVY strains during 2002-2007 revealed that virus population included mainly a novel recombinant isolate group, which was temporarily named as PVY^{SYR}. Isolates of PVY^{SYR} shared high genomic identity and close phylogenetic relationships with PVY^{NTN} and PVY^{NW} Syrian isolates. All PVY^{SYR} isolates induced veinal necrosis on tobacco plants but reacted with PVY^{O} MAb, which are typical characteristics of the previously reported PVY^{NW} (or $PVY^{N:O}$). However, four tested isolates induced potato tuber necrotic ringspot which is the characteristic phenotype of PVY^{NTN}. Shared properties of PVY^{SYR} isolates with PVY^{NTN} and PVY^{NW} suggested that they could represent a new recombinant strain of PVY^{N} strain group with the proposed name of PVY^{NTN-NW} (Chikh Ali *et al.,* 2009).

Another detailed characterization of a number of PVY^{SYR} isolates was conducted. Recombination analysis grouped isolates of PVY^{SYR} into three recombination patterns: SYR-I, SYR-II and SYR-III. PVY^{SYR} isolates shared highest genomic identity and close phylogenetic relationships with PVY^{NTN} and PVY^{NW} isolates from Syria, suggesting a common origin and local emergence of these isolates in the country. Given the shared properties of SYR-I and SYR-II with PVY^{NTN} and PVY^{NW} represented a new recombinant strain of PVY^{N} strain group with the proposed name PVY^{NTN-NW} (Chikh Ali *et al.,* 2010). Five local isolates of PVY were also characterized. Veinal necrosis symptoms were produced by all tested isolates on *Nicotiana tabacum* and reacted strongly with PVY polyclonal antibodies (PAbs). Reverse transcription polymerase chain reaction (RT-PCR) showed that the isolate L1 (from Latakia) was infected with PVY^{NTN-NW} and PVY^{NTN}, whereas H2 (Hama) and K5 (Al-Qaunaitara) isolates belonged to PVY^{NW}. Meanwhile, D3 (Damascus) and A4 (Aleppo) isolates belonged to PVY^{NTN}. The alignments of nucleotide sequences of the tested isolates with other isolates from GenBank showed 97-99% nucleotide sequence homology between the Syrian isolates and an isolate from the United State of America, and 83-98% homology between tested isolates and isolates from USA, an isolate from United Kingdom and an isolate from Germany (Mobayed *et al.,* 2014).

Hundreds of PVY isolates also were serologically characterized. They were classified into four serogroups, PYV^{O}, PYV^{N} and PYV^{C} represented 45.8, 33.3 and 4.2% of the isolates, respectively and 1.4% of the isolates did not react with any of the MAbs. 15.3% of isolates reacted with more than one MAb, 92.7% of them reacted positively with both PVY^{O} and PVY^{N} MAbs. PVY^{O} was the most frequent in all governorates, except for Homs, where PVY^{N} was the most frequent. Meanwhile PVY^{C} was recorded only in Homs and Hama (Al-Chaabi *et al.,* 2016).

Finally, some PVS local isolates were characterized, they infected *Chenopodium amaranticolor* only locally and were classified as PVS^{O}. PVS isolates classified into two main clusters, O and A, and cluster-O was separated into two subclusters (O1 & O2), two isolates were in O1 subcluster. The isolate PVS3-5 shared the highest nucleotide identity with European isolates from O1 subcluster, meanwhile, PVS6-2 isolate was closely related to Asian isolates of the same subcluster (Chikh Ali *et al.,* 2008).

Sweet potato viruses

The first report of sweet potato viruses was by Ismail and his colleagues (Ismail *et al.,* 2004b). They conducted a survey to investigate nine viruses infecting this crop in six regions of Latakia governorate during 2000-2002. Sweet potato feathery mottle virus (SPFMV) and CMV were recorded for the first time either in single or in mixed infections at the following rates: 3.07% for SPFMV, 40% for CMV and 47.17% as mixed infection of both viruses. SPFMV was graft-transmissible to *N. tabacum*, *N. benthamiana*, *Ipomoea setosa*, *I. nil*, and *Chenopodium quinoa*. CMV was also graft-transmissible to *N. glutinosa*, *N. benthamiana* and *N. tabaccum*, but it was not mechanically sap-transmissible. It was possible to differentiate between virus strains by using indicator plants (Akel *et al.,* 2007; Ismail *et al.,* 2004b; 2006a). Later on, a survey of eleven sweet potato viruses in five regions of the Syrian coast was conducted during 2006-2008. SPFMV and CMV were only recorded either singly or in mixed infections at 56.88, 3.91 and 8.53%, respectively. The highest rate of SPFMV infection was in Zagrin at 77.85%, and CMV in Sarsakia at 9.42% (Akel *et al.,* 2010a).

A study was conducted to differentiate between SPFMV isolates by grafting on indicator plants. Depending on symptoms variations, the isolates were divided into four groups: (i) very severe isolates with leaf malformation and stunting; (ii) severe isolates with chlorosis; (iii) mild isolates with mosaic and leaf curl and (iv) symptomless isolates (Akel *et al.,* 2008).

Finally, during 2006-2008 a survey was conducted along the Syrian coast to investigate the natural weed hosts of SPFMV. Nineteen species were recorded for the first time as natural hosts of this virus (Akel *et al.,* 2010b).

Tomato viruses and phytoplasmas

The first survey of viruses infecting tomato was conducted in southern Syria during 1998-2003 by Kawas (2007a). AMV, CMV, PVY, TMV, Tomato yellow leaf curl virus (TYLCV) and TSWV were recorded. Many surveys were conducted later, one in the central and coastal regions, where CMV was one of the viruses recorded (Khalil, 2007). Another expanded survey during the period 2007-2008 was carried out to investigate the presence of TSWV in eight governorates. The overall average infection of this virus in tested samples was 11.1% and the highest spread of the virus was in Al-Qunaitara (41%) followed by Dar'a, Damascus countryside, Aleppo, and Idleb (21.8, 12.0, 2.6, 1.8%), respectively. Virus identity was confirmed by one-step RT-PCR, and the Syrian isolates were found very similar at the nucleotide sequence level (97.74 to 99.84% of identity) and amino acid sequence level (96.17 to 99.03% of identity). Phylogenetic tree showed high similarity of Syrian isolates with many other representative isolates from different countries (Ismaeil *et al.,* 2009; 2010; 2012a; 2015). In the same survey, Tomato mosaic virus (ToMV) was also detected, with average incidence of 18.5%. The highest infection rate in tested samples and in the fields was recorded in Dar'a (27.1 and 2.7%) followed by Homs, Al-Qunaitara, Idleb, Damascus countryside, and Tartous (22.7 and 1.1, 21.3

and 2.1, 7.2 and 0.4, 5.2 and 0.5, 2.0 and 0.1%), respectively. Seed transmission rate of the virus in tomato seedlings was 16.7%. Virus occurrence in tomato was confirmed by one-step RT-PCR. That was the first record of ToMV on tomato in Syria (Ismaeil *et al.,* 2011; 2012b; 2014).

Pepino mosaic virus (PepMV) was recorded for the first time on tomato plants grown in greenhouses in Syria. The isolates shared highest sequence identity with EU-tomato strains (Fakhro *et al.,* 2010). Another survey was conducted along the Syrian coast during 2006-2007, with rates of natural infection with Tomato ring spot virus (ToRSV), TMV, PVY and TSWV reported were: 2.58, 2.24, 1.89, and 0.86%, respectively (Akel *et al.,* 2012). TYLCV was investigated in field and greenhouse tomatoes in Latakia and Tartous during 2008-2010. The overall virus incidence was 31.4%, whereas its incidences in Latakia and Tartous fields were 35.5 and 30.96%, respectively (Hasan *et al.,* 2013).

A survey of TSWV on some solanaceous crops and associated weeds was conducted during 2013 in Latakia. The infection rate in field crops was 8.82% on solanaceous and 62.5% on weeds, meanwhile, it was 2.11% on solanaceous crops and 85.71% on weeds in greenhouses. That was the first report of this virus on eggplant, and several weeds in Syria (Halabi & Akel, 2014). In another survey, TSWV and TYLCV infections in some important crops along the Syrian coast were found prevalent at all locations either in single or mixed infections (26.04 and 32.79% as single infection by each virus, respectively, and 14.14% as mixed infection). The highest rate of TSWV infection was 50% in Setkheres, and 54.54% for TYLCV in Yahmour and mixed infections rate in tomato was 25.45% (Akel *et al.,* 2019).

In 2017, virus symptoms (mild to severe mosaic on the apical leaves, brown necrosis on sepals, receptacle and flowers cluster carrier, and severe brown rugose and discoloration on fruits) were observed on tomato plants grown in a greenhouse in Akkar plain, Tartous. In 2020, leaf samples from symptomatic and asymptomatic plants (from Tartous and Latakia) were collected and tested serologically for the presence of Tomato brown rugose fruit virus (ToBRFV), and all symptomatic samples were found infected with the virus. Mechanical sap inoculation of a tomato cultivar using a positive tomato isolate gave systemic mosaic symptoms in all plants identical to those observed in the original plants in the field after 13 days of inoculation, and necrotic local lesions on *N. tabacum* after five days. ToBRFV infection was confirmed by RT-PCR, and two selected RdRp-specific PCR amplicons were purified and ligated, and three clones were sequenced and deposited in GenBank. The nucleotide sequences were 99.77 to 100% identical and shared around 99% identity with a Turkish isolate. That was the first report of this virus on tomato in Syria (Ismail *et al.,* 2020; Hasan *et al.,* 2021).

Seven tomato cultivars were inoculated mechanically with a local TMV isolate. Stunting of inoculated plants was observed (56% in Evaline and 78% in Carmello–Fl) with reduction of root system, and the leaves were pale-green to purple (Ra`ai & Ismail, 2000). Seed transmission of AMV (1.3%) and CMV (2.4%) in tomato seeds was reported (Ra`ai, 2011).

Twenty imported tomato hybrids were evaluated for their reaction to infection with ToMV under artificial inoculation conditions in the open field during 2009. Likewise, 15 local genotypes were evaluated against the same virus in a growth chamber under artificial inoculation conditions. Seven out of 20 hybrids were not infected and the yield loss of infected hybrids ranged between 32 and 55%. All local tomato genotypes were susceptible to infection with ToMV (Ismaeil *et al.,* 2012c).

In 2012, a study was carried out to evaluate the effect of single and mixed infections with PVY and CMV on tomatoes grown in a greenhouse in Tartous. Mixed infections with both viruses caused slight and weak effects and produced 5.5 and 4.25 clusters per plant, 65.68 and 65.68% fruit setting, 4.8 and 3.64 cm fruit diameter and 1.94 and 0.96 kg yield per plant, respectively. When the plants were first inoculated with CMV and later with PVY, the effect of CMV was prominent, whereas, when the first inoculation was with PVY, it suppressed the effect of the subsequent infection by CMV (Al-Shami & Ismail, 2013; 2014).

Six Syrian isolates of ToMV were characterized by RT-PCR and their genomic sequences were deposited at GenBank. Tested isolates had 99.56 to 100% sequence homology between them, whereas, homology at the amino acids level ranged between 99.33 and 100%. Phylogenetic tree showed high similarity between Syrian and Asian isolates and one isolate from Australia. The sequence homology ranged between 98 and 99% at nucleotide level (Ismaeil *et al.,* 2013).

TYLCV isolates collected from the Syrian coast were characterized, and two types TYLCV-Mld and TYLCV-IL were reported on tomato plants grown in greenhouses. TYLCV-Mld strains showed a high similarity between them (95.6% nucleotide homology) (Hasan & Mouhanna, 2016). Many studies were conducted to evaluate the efficiency of some bacteria species and some plant growth promoting rhizobacteria (PGPR) on CMV- and TYLCV-infected tomato plants to induce systemic resistance under greenhouse conditions. Generally, treatment with those bacteria or PGPR caused significant reduction in disease severity of both viral infections. Peroxidase enzyme activity in treated plants was increased and the growth of plants was improved and CMV symptoms were reduced. In addition, treatments of CMV-infected tomato plants by some PGPR increased the total phenol and photosynthesis pigments contents (Ismail *et al.,* 2016; 2017; Kawas *et al.,* 2017a; 2017b; 2018; Al-Shami *et al.,* 2017; Akel *et al.,* 2020; Ghanem *et al.,* 2021).

The presence of the Spanish strain (TYLCSV-ES) was confirmed and characterized by PCR in some TYLCV infected tomato plants in the greenhouses at the Syrian coast. The isolates To11 and To18 clustered in the same subgroup in the phylogenetic tree, showing 99.1% of nucleotide homology. This subgroup clustered in one group with TYLCSV-ES 5a from Morocco with 97 and 97.4% nucleotide identity, respectively. To6 clustered in the same subgroup with TYLCSV-ES from Almeria, Spain with 99.5% nucleotide identity (Hasan & Mouhanna, 2022).

Finally, symptoms (twisting, corrugated, yellowing or reddening of leaves, hypertrophied sepals of the flowers fused together and created a bell-shaped sterile bud of green or anthocyanin colour, stems were lignified with phloem necrosis) similar to those produced by Big bud phytoplasma disease were observed since 2013 on field tomatoes in Homs. In 2017, a phytoplasma of clover proliferation subgroup 16SrVI-A, or 'Candidatus phytoplasma trifolii' was identified and associated with such symptoms (Khalil *et al.*, 2019a; 2019b).

Pepper viruses

The first report on pepper viruses in Syria was by Daas *et al.* (2007), who conducted a survey during the period 2004-2005 to investigate the occurrence of AMV, CMV, TSWV, PVY and TMV on pepper crop. Infection rates ranged between 20 and 95% and the rate of single infection was 37.5% and mixed infections with two or three viruses were 9.39 and 5.3%, respectively. TMV was the most prevailing virus at 7.34% followed by AMV (4.9%), TSWV and PVY (3.61%) and least by TMV (2.44%).

Later on in 2006, other surveys were conducted, and CMV, TMV, PVX, PVY and AMV in four governorates in central and coastal regions of Syria were detected to infect pepper. CMV was the most spread virus (50.7%), followed by AMV (22.2%), TMV (17.8%), PVY (14.4%) and PVX (10.8%). CMV, TMV and PVY prevailed in the coastal region at 34.4, 23.7 and 18.3%, respectively, whereas CMV and AMV prevailed in the central region at 55.2 and 24.9%, respectively. CMV seed transmission (65%) was higher than AMV (15%) in pepper (Ismail *et al.*, 2007c; 2008).

An expanded survey was conducted during 2007-2008 to evaluate the spread of TSWV on pepper in eight governorates. Total infection rate was 41.2% of tested samples, meanwhile the general virus incidence in the fields was 3.1%. Damascus countryside had the highest virus incidence in the field of 20%, followed by Dar'a (12.9%) and Hama (0.8%) (Ismaeil *et al.*, 2009; 2010; 2015). In the same survey, ToMV was recorded on pepper for the first time in Syria. Virus infection average was 8.8% and its incidence in the field was the highest in Tartous (6.8%), followed by Idleb, Aleppo and Dar'a (0.3, 0.2 and 0.1%, respectively). The identity of TSWV was further confirmed by one-step RT-PCR (Ismaeil *et al.*, 2011; 2012b).

Pepper mild mottle virus (PMMV) and CMV were surveyed in Tartous and Latakia. PMMV was found in 0.39% and CMV in 11.42% of tested samples. PMMV seed transmission ranged between 0.7 and 0.87%, meanwhile, CMV seed transmission was higher (2.81-7.98%) (Ismail & Abbas, 2013).

TSWV and TYLCV were found to infect pepper in single or mixed infections. The infection rate of TYLCV in pepper was 51.31% (Akel *et al.*, 2019). The two strains TYLCV-Mld and TYLCV-IL identified earlier to infect tomato were also detected in pepper plants grown in greenhouses along the Syrian coast by PCR (Hasan & Mouhanna, 2016).

Many studies were implemented during the few last years to evaluate the effect of CMV and TYLCV infections on pepper plants and their growth parameters and to evaluate the effect of some bacterial strains and some biological fertilizers and salicylic acid to reduce CMV infection. CMV and TYLCV infections affected all growth parameters and the yield of pepper plants negatively. In addition, CMV infection significantly increased the proline and hydrogen peroxidase contents in the plants. Application of bacterial strains increased the growth parameters and yield of infected plants. The treatments with the biological fertilizers and salicylic acid reduced CMV infection and peroxidase enzyme activity was increased in the presence and absence of virus infection. The treatments improved plants growth, productivity, and stimulated systemic resistance against the virus (Al-Ajouriyeh *et al.*, 2016; 2021a; 2021b; 2021c; 2022; Hamdan *et al.*, 2021; Ibrahim *et al.*, 2020a; 2020b; Ismail *et al.*, 2015; Moalla *et al.*, 2020a; 2020b).

More recently, virus symptoms (chlorosis, mosaic and leaf discoloration accompanied with brown stems and fruit deformation) were observed in early 2020 on sweet pepper plants cultivated in greenhouses in Tartous. ToBRFV was detected serologically and reported for the first time in Syria in all symptomatic samples and its presence was further confirmed by RT-PCR. 99.78% similarity between Syrian and Lebanese isolates and 99.56% nucleotide identity with a Turkish isolate were observed (Abou Kubaa *et al.*, 2021). Finally, WMV was recently recorded on pepper for the first time in the country at a relatively low incidence of 2.94% (Mouhanna *et al.*, 2021).

Eggplant viruses

The first survey of eggplant viruses was conducted by Haj Kassem & Refai during 2004-2006 (Haj Kassem & Refai, 2009). Nine viruses were reported on solanaceous crops including eggplant. Later on, another survey was carried out during 2013 to investigate the presence of TSWV on eggplant in Latakia, and it was found that this crop was infected with this virus showing 31.94% of infection rate in the tested samples. That was the first report of TSWV on eggplant in Syria (Halabi & Akel, 2014).

Cucurbits viruses

The first report of viruses infecting cucurbit crops in Syria was carried out by Katul and Makkouk in 1985 (Katul & Makkouk, 1987) through a field survey conducted in northern Syria. Zucchini yellow fleck virus (ZYFV), Watermelon strain of Papaya ringspot virus (PRSV-W), Watermelon mosaic virus 2 (WMV-2) and CMV were present in 58.7, 76.1, 41.3 and 95.6% of tested samples, respectively.

After a decade, many surveys were conducted to investigate the presence of virus infections on cucurbits. During 1996-2001, a survey was conducted in southern Syria and eleven viruses were naturally reported. Zucchini yellow mosaic virus (ZYMV) was the most common one at 62.6% in squash. Infection rates of all tested viruses were as following: ZYMV (57.7%), PRSV (32.8%), Squash mosaic virus (SqMV) (23.8%), TSWV (23.2%), CMV (23.1%), Cucurbit aphid-borne yellow virus (CABYV) (22.6%), WMV-2 (19.7%), ZYFV (13.6%), AMV (8.5%), Melon necrotic spot virus (MNSV) (5%) and Cucumber green mottle mosaic virus (CGMMV) (5%). CABYV and TSWV were recorded on cucurbits for the first time in Syria (Kawas, 2007).

Another field survey was conducted during 1999-2001 in six governorates. Eight viruses were reported, and ZYMV was the most common virus, followed by CMV, WMV-2, SqMV, CGMMV and MNSV. Virus incidences in tested samples infected with one virus, two viruses and three or more viruses were: 16.8, 30.8 and 34.5%, respectively. That was the first record of ZYMV, CGMMV, MNSV and SqMV on cucurbits in Syria (Haj Kassem *et al.,* 2005). Later on, a survey was conducted during 2003-2004 on watermelon and melon in four governorates. ZYMV and WMV were present at an incidence of 18.33 and 15.1%, respectively. 9.24 and 15.84% of tested watermelon samples were infected with ZYMV and WMV, and for melon 58.82 and 11.77%, respectively. The highest ZYMV and WMV incidence on the two crops was recorded in Idleb (53.01%), and the lowest was in Daraa (16.81%) (Al-Chaabi *et al.,* 2006).

Another survey was conducted on squash in southern Syria during 2004-2006. Fourteen viruses were detected, ZYMV was detected in 59.9% of the tested samples, followed by WMV (38.3%), CMV (34.0%), PRSV (24.8%), CGMMV (23.4%), Squash leaf curl virus (SLCV) (22.9%), TSWV (4.5%), Lettuce mosaic virus (LMV) (3.17%), Tomato black ring virus (ToBRV) (2.8%), SqMV (2.35%), Arabis mosaic virus (ArMV) (0.59%), ToRSV (0.23%), TRSV (0.23%) and AMV (0.23%). That was the first record of LMV, ArMV, ToBRV, TRSV, ToRSV and SLCV on squash in Syria (Al-Tamimi *et al.,* 2009a). In the same survey, seed transmission of squash viruses during 2006-2007 was assessed. Eight viruses were found to be seed-transmitted: CMV was the most common seed-transmitted virus (2.4%), followed by ArMV (0.27%), ToRSV (0.23%), ZYMV (0.04%), TSWV (0.12%), ToBRV (0.15%), SqMV (0.08%), CGMMV (0.08%). Seed transmission was lower in imported seeds (0.25%) than local ones (0.64%). Virus incidence in all seeds was 1.47%. That was the first record of seed transmission of ArMV, ToRSV, TSWV and ToBRV in squash (Al-Tamimi *et al.,* 2009b; 2009c).

The incidence of ZYMV, WMV and CMV on cucurbits (Squash, cucumber, melon, watermelon and pumpkin) in five governorates was investigated during 2006-2007. 83.9% of tested samples were infected with one or more viruses. ZYMV was detected in 67.9% of the tested samples followed by WMV (39.9%) and CMV (10.8%). Infection with ZYMV squash isolate was confirmed by RT-PCR (Mando *et al.,* 2009; 2011a). Reaction of some local accessions and imported hybrid cultivars of squash and melon was evaluated by artificial inoculation with ZYMV during 2009. Three squash hybrids were found resistant, and two squash and one melon cultivars were found moderately resistant. Four commercial cultivars labelled as ZYMV resistant, were shown to be susceptible under local field conditions (Mando *et al.,* 2011b).

A study was conducted in Latakia during 2012-2013 to determine the effect of salicylic acid as inducer of systemic acquired resistance to CMV in mechanically inoculated cucumber plants. CMV infected plants treated with salicylic acid gave better vegetative growth and higher productivity (Samra *et al.,* 2015).

Two strains of TYLCV (TYLCV-Mld and TYLCV-IL) were identified on cucumber plants grown in greenhouses along the Syrian coast by PCR (Hasan & Mouhanna, 2016). More recently, a study aimed to identify some local isolates of WMV on cucurbits in Latakia and Tartous was carried out. The virus was detected in watermelon, squash, pumpkin and cucumber, at relative incidences of 36.95, 26.31, 29.27 and 37.70%, respectively. Virus presence was confirmed by RT-PCR, and the local isolate (Cu4) was grouped with an Iranian isolate at 98.9% sequence identity. Meanwhile, the isolate Wa2 was in the same group with a Turkish isolate at 98.3% sequence identity, and the isolates Zu6 and Cu8 represented one sub-group at 99.3% sequence identity (Mouhanna *et al.,* 2021).

Legumes viruses

The first report of legumes viruses in Syria was by Makkouk *et al.* (1986; 1987). In 1988, nine viruses were recorded on faba bean through a field survey conducted in six Arab countries, including Syria. The most widely spread virus was Bean leaf roll virus (BLRV), followed by Bean yellow mosaic virus (BYMV), Broad bean mottle virus (BBMV) and BBSV. Other viruses were recorded: Broad bean true mosaic virus (BBTMV), Broad bean wilt virus (BBWV), CMV, Pea enation mosaic virus (PEMV) and Pea seed-borne mosaic virus (PSbMV). The average of seed transmission rate was 1.2% with either BBSV, BYMV or PSbMV (Makkouk *et al.,* 1988; 1992a; 1992b; Makkouk & Kumari, 1992).

In 1992, suspected leaf yellowing and necrotic virus symptoms observed on faba bean in Latakia was found associated with virus particles with a circular single stranded DNA (Katul *et al.,* 1993). This virus was named Faba bean necrotic yellows virus (FBNYV), persistently transmitted by many aphid species. A Syrian local isolate was purified and an antiserum against the virus was produced (Makkouk *et al.,* 1992c).

In a field survey conducted in the Syrian coast during l99l-1993 showed that FBNYV, BYMV, Beet western yellows virus (BWYV), BBSV, Chickpea luteovirus (CpLV), BLRV, BBMV, CMV, AMV, BBWV and PSbMV were detected in cool season legumes. FBNYV was the most common virus followed by BYMV (Mouhanna *et al.,* 1994). Ten viruses (BLRV, FBNYV, AMV, CMV, BBMV, BBWV, PSbMV, BYMV, BBSV and BBTMV) were detected by a new sensitive detection method named tissue blot immunoassay (TBIA) using polyclonal (PAbs) and monoclonal (MAbs) antibodies. The test was practical using a nitrocellulose membrane and can be more easily used as compared with ELISA. It can be completed in less than four hours and it is cheaper and does not require sophisticated facilities (Makkouk & Kumari, 1996).

Soybean dwarf virus (SbDV) was detected in faba bean and pea in northern Syria (Nassan *et al.,* 1997). During 1995-1997, field surveys were conducted at El-Ghab plain to investigate viruses infecting legumes. FBNYV was the most common virus in faba bean fields (60%) (Hassan *et al.,* 1997; 1999). Furthermore, a survey was conducted in four countries, including Syria during 1994-1996. Three luteoviruses were reported in Syria: BLRV, SbDV and BWYV in addition to FBYNV and Chickpea chlorotic dwarf virus (CpCDV) (Kumari *et al.,* 1997).

A field experiment was conducted in 1997 aimed to study the effect of the insect pesticide (Imidacloprid, Gaucho) to reduce the incidences of BLRV and FBNYV through controlling their aphid transmission vectors. Treatment of faba bean seeds before planting with the pesticide gave significant decrease in both viruses infection rates (Makkouk & Kumari, 1997).

In 2005, a survey was conducted to identify some viruses infecting faba bean in Syria. FBNYV was the most common virus at 2.31% incidence, followed by BWYV, BLRV and SBDV at 1.61, 0.57 and 0.11%, respectively (Ismail *et al.*, 2006b). BWYV was detected mainly on legumes species through a survey conducted during 2006-2007 (Asaad *et al.*, 2009). A study was conducted to identify virus infection of weeds spread in faba bean fields along the Syrian coast. Five weed species were found infected with FBNYV and eight species infected with BYMV (Ismail & Hasan, 2007).

Many surveys conducted in West Asia and North Africa (WANA) countries including Syria during the past thirty years by the International Center for Agricultural Research in the Dry Areas (ICARDA). These surveys showed that the major economic importance viruses of legumes in general and especially of faba bean are: FBNYV, BLRV, BYMV, BBMV and PSbMV. Other viruses such as AMV, BWYV, BBWV, BBTMV, BBSV, CCDV, CMV, Pea early browning virus (PEBV), PEMV and SbDV were also detected (Kumari & Makkouk, 2007; Kumari *et al.*, 2008; Makkouk & Kumari, 2009; Makkouk *et al.*, 2012; 2014).

A field survey was conducted to determine the spread of BYMV on food legumes and weed species during 2004-2007. The virus was detected in all surveyed areas with the highest incidence on faba bean in the coastal region and was also detected in three weed species. Furthermore, it was found that this virus had a significant effect on the yield of a local cultivar of faba bean under field conditions (Alkhalaf *et al.*, 2010).

PSbMV was detected in the seeds of cowpea in Latakia governorate for the first time (Ismail & Darwish, 2013). Chickpea chlorotic stunt virus (CpCSV) was surveyed and detected in Latakia, with the highest rate of 33.33% in Ras-Elain and the lowest was 7.69% in Elbourjan (Ismail & Abbas, 2014).

When the effect of pre-sowing of faba bean seeds treatment with two insecticides (Thiamethoxam & Imidacloprid) on reduction the incidence of BLRV was evaluated, a reduction in viral infection rate from 85 to 19% in Thiamethoxam treatment was noticed, and such reduction had a significant positive effect on yield. Similar results were obtained following Imidacloprid treatment (Kumari *et al.*, 2007). Another experiment was conducted under artificial infection conditions in a glasshouse during 2007 to evaluate the movement and multiplication of BYMV in faba bean and pea genotypes. The systemic movement and multiplication of the virus were slower in the resistant than in the susceptible genotypes (Alkhalaf *et al.*, 2009). Two strains of TYLCV (TYLCV-Mld and TYLCV-IL) were identified on bean plants in the Syrian coast by PCR (Hasan & Mouhanna, 2016).

Seed transmission of BYMV, BBMV and PSbMV was studied in seeds of TEMA-Beans and Pea-America and Pea-Holland cultivars. The highest seed transmission rate of PSbMV varied as follows: 11.6 % in TEMA-Beans, 9.80 % in Pea-Holland and 7.92 % in Pea-America. Seed transmission of BBSV was 8.19% of tested samples and was only in TEMA-Beans at 24.16%. Seed transmission rate of BBMV was highest (10 %) in TEMA-Bean seeds and was not reported in Pea-America seeds, and 4.5 % in Pea-Holland seeds (Abbas & Darwish, 2017).

Finally, a research was carried out during 2017-2018 in Latakia aimed to study the effect of plant density and CMV infection on some morphological traits of faba bean plants. Five plants/m^2 density was superior to 10 and 20 plants/m^2 in number of branches, fresh weight of leaves and leaves area at the pods formation stage (Mohamad *et al.*, 2020).

Garlic viruses

The first report of garlic virus diseases in Syria was by Kawas (2003). Garlic common latent virus (GCLV) and Shallot latent virus (SLV) were reported in Damascus countryside. Later on, Onion yellow dwarf virus (OYDV) and Leek yellow stripe virus (LYSV), GCLV and SLV were detected in a survey conducted during 2002-2003 and 2003-2004 growing seasons in southern Syria. OYDV was the most common virus, followed by GCLV, LYSV and least by SLV. In the first growing season, virus incidences were: 72.7, 37.04, 38.38 and 32.84% by OYDV, GCLV, LYSV, SLV, respectively. Meanwhile, they were 52.05, 39, 26.4 and 17.6% during the next season (Mohammad *et al.*, 2007).

Conclusions

Until present, no field surveys were conducted to identify virus diseases on cruciferaceous crops and no viruses, viroids and phytoplasmas were reported so far on these crops grown in Syria. It is strongly recommended to carry out such surveys to evaluate the sanitary status of these crops as well as the other vegetable crops grown in the country and trying to identify the responsible causal agents. It is likely that these vegetable crops are infected with viral pathogens, especially because of suspicious viral symptoms were observed regularly on these vegetable crops.

Furthermore, additional surveys should be carried out to identify the causal agents of phytoplasma diseases on different vegetable crops grown in the country. Strict quarantine measures must be applied at the borders to limit the spread of these diseases from the neighbouring countries which are already reported some phytoplasmas, such as Lebanon on solanaceous crops (Choueiri *et al.*, 2007) and Jordan on tomato and potato crops (Anfoka *et al.*, 2003; Salem *et al.*, 2019).

From the above-mentioned reports, it could be concluded that nearly 51 different viruses and one phytoplasma were reported on solanaceous crops (potato, tomato, sweet potato, pepper and eggplant), cucurbits, legumes and garlic in Syria (Table 1). Generally, it is clear that the sanitary status of most vegetable crop species previously investigated is unsatisfactory and in some of them virus incidence in the field was very high.

Urgent approaches must be followed to manage these virus diseases and to reduce the economic losses they cause. It is well known that there are no specific pesticides or chemical treatments that can be applied to control plant virus diseases in general. Adoption of integrated virus diseases management approaches would be the best approach to minimize yield losses caused by them.

Thus, the first step is to accurately identify the pathogens involved by applying the appropriate diagnostic (biological, serological and molecular) methods. The second important step is the exclusion, to prevent the virus from entering the production systems. That includes using virus-free certified seeds followed by using integrated pest management (IPM) practices to prevent or reduce infections in the field, especially at the transplanting stage. The other important practice is the eradication of the reservoir hosts by removing the initial sources of virus infections, which are the infected weeds and volunteer crop plants in vegetable crops fields. In addition, destruction of the old crop once harvested is a good and effective way to dispose of virus potential reservoirs.

Finally, one of the most effective methods to control virus diseases in vegetable crops is planting resistant cultivars against viruses and trying to produce regularly new resistant cultivars and search for resistance genes in wild species of these vegetable crops to prevent the development of resistance breaking strains of the viruses.

Table 1. Viruses and phytoplasmas reported on vegetable crops in Syria.

Viruses & Phytoplasmas	Abbreviation	Genus	Family	Hosts	References
Alfalfa mosaic virus	AMV	*Alfamovirus*	*Bromoviridae*	Potato, tomato, pepper, cucurbits & legumes	Haj Kassem *et al.*, 2007b; Kawas, 2007a, 2007b; Daas *et al.*, 2007; Mouhanna *et al.*, 1994
Arabis mosaic virus	ArMV	*Nepovirus*	*Secoviridae*	Cucurbits	Al-Tamimi *et al.*, 2009a
Bean leafroll virus	BLRV	*Luteovirus*	*Tombusviridae*	Legumes	Makkouk *et al.*, 1988
Bean yellow mosaic virus	BYMV	*Potyvirus*	*Potyviridae*	Legumes	Makkouk *et al.*, 1988
Beet western yellows virus	BWYV	*Polerovirus*	*Solemoviridae*	Potato, tomato, pepper, eggplant & legumes	Haj Kassem & Refai, 2009; Mouhanna *et al.*, 1994
Broad bean mottle virus	BBMV	*Bromovirus*	*Bromoviridae*	Legumes	Makkouk *et al.*, 1988
Broad bean stain virus	BBSV	*Comovirus*	*Secoviridae*	Legumes	Makkouk *et al.*, 1988
Broad bean true mosaic virus	BBTMV	*Comovirus*	*Secoviridae*	Legumes	Makkouk *et al.*, 1988
Broad bean wilt virus	BBWV	*Fabavirus*	*Secoviridae*	Legumes	Makkouk *et al.*, 1988
Chickpea chlorotic dwarf virus	CpCDV	*Mastervirus*	*Geminiviridae*	Legumes	Kumari *et al.*, 1997
Chickpea chlorotic stunt virus	CpCSV	*Polerovirus*	*Solemoviridae*	Legumes	Ismail & Abbas, 2014
Cucumber green mottle mosaic virus	CGMMV	*Tobamovirus*	*Virgaviridae*	Cucurbits	Kawas, 2007b
Cucumber mosaic virus	CMV	*Cucumovirus*	*Bromoviridae*	Potato, Sweet potato, tomato, pepper, eggplant, cucurbits & legumes	Chikh Ali *et al.*, 2008; Ismail *et al.*, 2004b; Kawas, 2007a, 2007b; Daas *et al.*, 2007; Haj Kassem & Refai, 2009; Makkouk *et al.*, 1988
Cucurbit aphid-borne yellow virus	CABYV	*Polerovirus*	*Solemoviridae*	Cucurbits	Kawas, 2007
Faba bean necrotic yellow virus	FBNYV	*Nanovirus*	*Nanoviridae*	Legumes	Makkouk *et al.*, 1992c
Garlic common latent virus	GCLV	*Carlavirus*	*Betaflexiviridae*	Garlic	Kawas, 2003
Leek yellow stripe virus	LYSV	*Potyvirus*	*Potyviridae*	Garlic	Mohammad *et al.*, 2007
Lettuce mosaic virus	LMV	*Potyvirus*	*Potyviridae*	Cucurbits	Al-Tamimi *et al.*, 2009a
Melon necrotic spot virus	MNSV	*Gammacarmovirus*	*Tombusviridae*	Cucurbits	Kawas, 2007
Onion yellow dwarf virus	OYDV	*Potyvirus*	*Potyviridae*	Garlic	Mohammad *et al.*, 2007
Papaya ringspot virus	PRSV	*Potyvirus*	*potyviridae*	Cucurbits	Katul & Makkouk, 1987
Pea early browning virus	PEBV	*Tobravirus*	*Virgaviridae*	Legumes	Kumari & Makkouk, 2007
Pea enation mosaic virus-1	PEMV-1	*Enamovirus*	*Solemoviridae*	Legumes	Makkouk *et al.*, 1988
Pea seed-borne mosaic virus	PSbMV	*Potyvirus*	*Potyviridae*	Legumes	Makkouk *et al.*, 1988
Pepper mild mottle virus	PMMV	*Tobamovirus*	*Virgaviridae*	Pepper	Ismail & Abbas, 2013
Pepino mosaic virus	PepMV	*Potexvirus*	*Alphaflexiviridae*	Tomato	Fakhro *et al.*, 2010
Potato aucuba mosaic virus	PAMV	*Potexvirus*	*Alphaflexiviridae*	Potato	Haj Kassem *et al.*, 2007b
Potato leaf roll virus	PLRV	*Polerovirus*	*Solemoviridae*	Potato	Haj Kassem *et al.*, 1997
Potato virus A	PVA	*Potyvirus*	*Potyviridae*	Potato	Haj Kassem *et al.*, 1997
Potato virus M	PVM	*Carlavirus*	*Betaflexiviridae*	Potato	Haj Kassem *et al.*, 1997

Viruses & Phytoplasmas	Abbreviation	Genus	Family	Hosts	References
Potato virus S	PVS	*Carlavirus*	*Betaflexiviridae*	Potato	Haj Kassem *et al.*, 1997
Potato virus X	PVX	*Potexvirus*	*Alphaflexiviridae*	Potato, tomato, pepper & eggplant	Haj Kassem *et al.*, 1997; Haj Kassem & Refai, 2009
Potato virus Y	PVY	*Potyvirus*	*Potyviridae*	Potato, tomato, pepper & eggplant	Haj Kassem *et al.*, 1997; Haj Kassem & Refai, 2009
Shallot latent virus	SLV	*Carlavirus*	*Betaflexiviridae*	Garlic	Kawas, 2003
Soybean dwarf virus	SbDV	*Luteovirus*	*Tombusviridae*	Legumes	Nassan *et al.*, 1997
Squash leaf curl virus	SLCV	*Begomovirus*	*Geminiviridae*	Cucurbits	Al-Tamimi *et al.*, 2009a
Squash mosaic virus	SqMV	*Comovirus*	*Secoviridae*	Cucurbits	Kawas, 2007
Sweet potato feathery mottle virus	SPFMV	*Potyvirus*	*Potyviridae*	Sweet potato	Ismail *et al.*, 2004b
Tobacco mosaic virus	TMV	*Tobamovirus*	*Virgaviridae*	Potato, tomato, pepper & eggplant	Haj Kassem & Refai, 2009
Tobacco rattle virus	TRV	*Tobravirus*	*Vergaviridae*	Potato, tomato, pepper & eggplant	Haj Kassem & Refai, 2009
Tobacco ring spot virus	TRSV	*Nepovirus*	*Secoviridae*	Potato, tomato, pepper, eggplant & cucurbits	Haj Kassem & Refai, 2009; Al-Tamimi *et al.*, 2009a
Tomato black ring virus	ToBRV	*Nepovirus*	*Secoviridae*	Potato, tomato, pepper, eggplant & cucurbits	Haj Kassem & Refai, 2009; Al-Tamimi *et al.*, 2009a
Tomato brown rugose fruit virus	ToBRFV	*Tobamovirus*	*Virgaviridae*	Tomato, pepper	Ismail *et al.*, 2020; Abou Kubaa *et al.*, 2021
Tomato ring spot virus	ToRSV	*Nepovirus*	*Secoviridae*	Tomato & Ecucurbits	Akel *et al.*, 2012; Al-Tamimi *et al.*, 2009a
Tomato spotted wilt virus	TSWV	*Orthotospovirus*	*Tospoviridae*	Potato, tomato, pepper, eggplant & cucurbits	Kawas, 2007a; Daas *et al.*, 2007; Haj Kassem & Refai, 2009; Kawas, 2007
Tomato yellow leaf curl virus	TYLCV	*Begomovirus*	*Geminiviridae*	Tomato, pepper & cucurbits	Kawas, 2007a; Akel *et al.*, 2019; Hasan & Mouhanna, 2016
Tomato mosaic virus	ToMV	*Tobamovirus*	*Virgaviridae*	Tomato & pepper	Ismaeil *et al.*, 2012b
Watermelon mosaic virus	WMV	*Potyvirus*	*Potyviridae*	Pepper & Cucurbits	Mouhanna *et al.*, 2021; Al-Chaabi *et al.*, 2006
Watermelon mosaic virus 2	WMV-2	*Potyvirus*	*Potyviridae*	Cucurbits	Katul & Makkouk, 1987
Zucchini yellow fleck virus	ZYFV	*Potyvirus*	*Potyviridae*	Cucurbits	Katul & Makkouk, 1987
Zucchini yellow mosaic virus	ZYMV	*Potyvirus*	*Potyviridae*	Cucurbits	Kawas, 2007b
Clover proliferation (Candidatus phytoplasma trifolii)	CP^{R}	*Phytoplasma*	*Acholeplasmataceae*	Tomato	Khalil *et al.*, 2019a, 2019b

الملخص

إسماعيل، فايز، جمال مندو، محمد الخلف وصفاء غسان قمري. 2023. الفيروسات والفايتوبلازما المسجلة على أهم محاصيل الخضروات في سورية: مراجعة علمية. مجلة وقاية النبات العربية، 41(4): 444-458. https://doi.org/10.22268/AJPP-41.4.444458

تشتهر سورية بزراعة العديد من محاصيل الخضروات المختلفة في معظم المحافظات خلال موسمي الزراعة الشتوي والصيفي كليهما، ويُعزى ذلك لظروفها المناخية المتوسطية المعتدلة التي تتسم بشتاء معتدل وصيف حارٍّ جاف. تُعّد زراعة الخضروات من أهم قطاعات الزراعة السورية، حيث تُمثل مصدراً مهماً للدخل بالنسبة للمزارعين، كما وتُعدّ مصدراً للعملة الصعبة من خلال التصدير. تنتمي أهم الخضروات المزروعة في سورية للباذنجانيات (بطاطا/بطاطس، بندورة/طماطم، بطاطا/بطاطس حلوة، فليفلة/فلفل وباذنجان)، القرعيات (بطيخ أحمر/جبس، بطيخ أصفر/شمام، خيار، كوسا ويقطين)، البقوليات (فول أخضر، فاصولياء، بازلاء خضراء ولوبياء خضراء)، الصليبيات (ملفوف أبيض وقرنبيط أبيض) وأنواع أخرى مثل: البصل الأخضر، الثوم الأخضر، الخسّ، البامياء، .. إلخ. تُصاب محاصيل الخضروات تلك بالعديد من الأمراض الناتجة عن مسببات مرضية مختلفة، من ضمنها الفيروسات، الفيرويدات والفايتوبلازما والتي تُعدّ من أهم المسببات المرضية للعديد من الأمراض الخطيرة بالغة التأثير. وخلال الأربعين سنة الماضية في سورية، تمّ تقصي انتشار العديد من الفيروسات وقليل من الفايتوبلازما، وقد سُجّل العديد منها (وبخاصةٍ الفيروسات) على محاصيل الخضروات من خلال عدة مسوحات حقلية أُجريت لتقويم حالتها الصحية وتحديد الخسائر الاقتصادية والأضرار الناجمة عن تلك المسببات

المرضية. تم القيام بعشرات الدراسات والبحوث في هذا المجال، والتي هدفت لتعريف تلك المسببات المرضية على أهمّ محاصيل الخضروات المزروعة في سورية، ولإيجاد الوسائل المناسبة والطرائق الفعّالة لمكافحتها. كما استخدمت العديد من طرائق الكشف وتقانات التشخيص المتوفرة والمناسبة (الحيوية/البيولوجية، المصلية/السيرولوجية والجزيئية) لتقويم الحالة الصحية لهذه المحاصيل.

كلمات مفتاحية: أمراض، محاصيل خضروات، فيروسات، فايتوبلازما، سورية.

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Received: September 13, 2022; Accepted: January 19, 2023

تاريخ الاستلام: 2022/9/13؛ تاريخ الموافقة على النشر: 2023/1/19