# Molecular detection of cucumber mosaic virus, its biological properties and transmission by *Rhizoctonia solani* in plastic houses of Duhok Province.

**Viyan Jameel Haji**

Department of Plant Protection, College of Agricultural Engineering Sciences, University of Duhok, Kurdistan Region, Iraq

*Corresponding author's email: viyan.kurd.2016@gmail.com

## Abstract

Cucumber mosaic virus (CMV; *Cucumovirus*, family *Bromoviridae*) is one of the most common viruses that infect cucumber plants and can affect a variety of important crops. In this study, 25 symptomatic cucumber plants showing mosaic and vein yellowing were randomly collected in November 2024 from various plastic houses of different regions of Duhok Province of Kurdistan Region of Iraq. (Based on the results of RT-PCR, the cucumber samples collected from the cultivated plastic houses located in different regions of Duhok were infected with CMV). *Cucumis sativus*, *Cucurbita pepo*, *Solanum lycopersicum*, *Capsicum annuum*, *Nicotiana tabacum*, *Vigna unguiculata*, *Zinnia elegans*, and *Chenopodium quinoa were* the plants used to determine the host range of the virus. Based on other findings, the transmission of CMV infection between cucumber plants by *Rhizoctonia solani* has been suspected to occur. (Depending on our results), *R. solani* was unable to acquire CMV from an infected plant in a controlled fungal inoculation experiment and was unable to transmit the virus to (healthy) cucumber plants. This is the first time that CMV has been detected in cucumber plants grown in greenhouses of Duhok Province, Kurdistan Region – Iraq.

**Keywords:** *Cucumis sativus*, cucumber mosaic virus *(*CMV), RT-PCR, (host range), *Rhizoctonia solani*[i].

## Introduction

Cucumber is considered one of the most economically and nutritionally important cucurbit crops that are produced in both fall and spring seasons in open and protected agriculture fields across Iraq (22). Cucumbers are a nutritious fruit with several health benefits in the family *Cucurbitaceae*. Cucumbers have fibre, manganese, magnesium, potassium, and vitamins A, C, and K. Furthermore, it maintains control of sugar, soothe the skin and blood pressure, are helpful in digestion, and regulate hydration. Additionally, it helps with weight loss by reducing fat. Moreover, Cucumbers can have antimicrobial and hydrating properties, prevent cancer, and detoxify the body. Economically, cucumbers are highly significant, as they contain medicinal and high nutritional as well as health-beneficial values (17). In 2024, global cucumber production was 88 million tons, whilst in Iraq, 129,110 tons (13). In addition to a decrease in planting area, plant diseases, especially plant viruses, have prevented cucumber production. (32). (CMV) is one of the most widespread viruses in the world that has a wide range of hosts (31).

CMV, a member of the *Cucumovirus* genus in the *Bromoviridae* family, is a non-

ISSN 2072-3857

enveloped (isometric virus) about 26-35 nm in diameter that contains a tripartite positive-sense single-stranded RNA genome (7). Typical symptoms of CMV are mosaic on leaves, yield reduction, mottling, very low spike filling, reduced spike length, and plant stunting (27). CMV can be transmitted from one plant to another by mechanical inoculation, seeds, and grafting (35).In nature, Aphids transmit CMV non-persistently to a wide range of natural hosts, including wild species and economically important crops. (3, 5, 24). Numerous investigations have shown that the soil-borne plant-pathogenic fungus *Rhizoctonia solani* carries a number of mycoviruses (11, 34).

This study reports the virus's host range and provides molecular identification of CMV in plastic houses grown by cucumbers in different regions of Duhok province. Furthermore, the transmission of CMV by *R. solani* under controlled environmental conditions was studied.

## Materials and methods

### Sampling of the virus

Sampling for virus-infected *C. sativus* plants was conducted in 2024 in the plastic houses of Duhok province, Kurdistan Region, Iraq. The leaves of 25 cucumber plants that appeared virally infected were randomly collected from various locations. The samples were collected from young leaves of cucumber plants showing typical mosaic and yellowing viral symptoms. Collected samples were wrapped in a polyethylene bag, labeled, and transported to the University of Duhok, College of Agricultural Engineering Sciences, Plant Pathology Laboratory. The collected samples were kept in a deep freezer at -18 ºC for viral detection and further studies (13)

### ؟Viral isolate propagation

Collected sample from the sampling was propagated in cucumber plants using the following procedure: The seeds of the cucumber plants were cultured in pots (20 pots/2 per pot) containing sterilized substrate and maintained under greenhouse conditions. The grown plants with 4–6 fully expanded leaves were dusted using carborundum and mechanically inoculated with CMV samples collected from the plastic houses of Duhok Province, Kurdistan Region, Iraq. The inoculum was prepared by grinding the collected samples from the sampling leaves in potassium phosphate buffer (pH 7.0) at 1:10 (w/v) in 0.01 M. In total, 40 plants were used as test plants for mechanical transmission with control plants. The inoculated plants were observed daily for symptom development 4–6 weeks after inoculation (14, 33).

؟؟؟؟؟

### RNA Extraction

Using a Viral RNA/DNA Extraction Kit (Catalog No. MDE106), BETA BAYERN Biotech Company, Bayern, Germany, total RNA was extracted from the collected leaves. For this purpose, 30 mg of the samples and 3.5 µl of β-mercaptoethanol were grinded in liquid nitrogen, and the obtained powder was mixed with 350 µl of lysis buffer. The samples were homogenized, and the solution was then allowed to sit at room temperature for five minutes. The samples were transferred to a filter column and then centrifuged for two min at 18,000 rpm. The supernatant was transferred to new microcentrifuge tubes. After adding 70% RNase-free ethanol (1

ISSN 2072-3857

volume), the mixture was vortexed. After adding 500 microliters of wash buffer 1 to the mini-column, it was centrifuged for one minute at full speed. After adding 750 microliters of wash buffer 2 to the mini-column, it was centrifuged for one minute at full speed. For another three minutes, the mini-column was centrifuged at full speed. The membrane center of the mini-column was filled with 100 microliters of RNase-free dd$H_2O$. After that, it was centrifuged for 1.5 minutes at full speed. The extracted RNA was stored at − -70°C.

**Virus identification using RT-PCR**

The partial Coat protein gene of CMV was amplified using RT-PCR to confirm the presence of the virus in collected *C. sativus* leaf samples. The primer pair (CMV F/CMV R) 5′-TTGAGTCGAGTCATGGACAAATC-3 ′ and 5′-was used as forward and reverse primers, respectively, with a 678 bp expected size. cDNA synthesis was conducted using the Beta Script Kit (Catalog No. MRT 105), BETA BAYERN Biotech Company, Bayern, Germany. The RT reaction mixture of 50 µl consisted of 25 µl of *Taq* DNA polymerase master mix, 3 µl of each forward and reverse primer (0.1 µM), 14 µl of PCR-grade water, and 5 µl of DNA template. Bioresearch PTC-200 Gradient thermocycler was programmed for amplification for 5 min at 95 °C in initial denaturation; 35 cycles of 95 °C for 35sdenaturation, 60 °C for 40 s annealing, and 1 min extension per 1 kbp product at 72 °C; and a final extension for 10 min at 72 °C. To a 1.5% agarose gel, ethidium bromide was added in 1X TBE buffer within the electrophoresis electric field. Using a UV trans-illuminator, the gel was inspected to identify the band (1). (After confirming the presence of the virus in cucumber leaf samples, the seeds were used to test the transmission of CMV by *R. solani* using RT-PCR).

**Host Range**

The RT-PCR positive samples were used to determine the host range and symptomology of the virus. In this aspect, the seeds of various plant species from various families were cultured in pots with a diameter of 25cm (10 pots/species). The cultured pots by various species seeds (3 seeds/ pot) contained sterilized substrate (sand 1:1 peat moss). The cultured pots were kept in a plastic house. The studied species were *Cucurbitaceae* (*Cucumis sativus* (Wasem var.), *Cucurbita pepo* (Tohum), *Solanaceae* (*Solanum lycopersicum* (Falcon), *Nicotiana tabacum* (local var.), *Capsicum annuum* (California Wonder)), *Fabaceae* (*Vigna unguiculata* (Ramshorn), *Asteraceae* (*Zinnia elegans*), and *Chenopodiaceae* (*Chenopodium quinoa*). The seeds of each species were tested previously for CMV-freeness using RT-PCR. Mechanical inoculation was used to transmit the virus to the grown host species. In this way, the leaves of the RT-PCR-positive samples were crushed at a 1:10 (w/v) ratio in 0.01 M potassium phosphate buffer (pH 7.0) to prepare the viral inoculum then the grown host species containing 4-6 fully expanded leaves were inoculated by the inoculum using forefingers. One month after inoculation, the inoculated plants were observed for symptom development (1).To obtain the desired results, mechanical inoculation was repeated twice (1, 2, 14).

**CMV transmission by *R. solani***

**Virus and Fungal Inoculation**

In this study, the virus-free seeds of *C. sativus* (Wasem var.) were grown in pots

ISSN 2072-3857

(10 pots/3 plants per each) containing the sterilized substrate and kept in a plastic house. The seeds were previously tested for CMV-freeness using RT-PCR. The fully developed plants with 4-6 leaves were inoculated with the virus sap as described before. To inoculate the CMV-inoculated cucumber plants with *R. solani*, 30 days post-viral inoculation, wounds were made using sterile toothpicks on the lower stems of plants, and the fungal mycelia were picked up from the edge of a three-day of the stem for 24 hours, and the plants were-old culture colony and placed into the wound. Parafilm was used to wrap the infected part maintained under greenhouse conditions (9).

**Acquisition of CMV by *R. solani***. To investigate the acquisition of CMV by *R. solani*, the fungus was reisolated from the inoculated plants using the following procedure. Small pieces (0.2 × 0.5 cm) of fungus-infested stem tissue were cut and washed with solutions containing 75–-80% ethanol, followed by multiple washes with sterilized distilled water. The pieces of stem tissue (approximately 5 per stem) were then placed in PDA medium containing streptomycin. Colonies were sub-cultured on fresh PDA medium after the fungus had grown. The fungi were confirmed for CMV acquisition by mechanical inoculation and RT-PCR (28).

To study the acquisition and transmission of CMV by *R. solani* using mechanical inoculation, the virus-free cucumber seeds were cultured in pots (10 pots/3 plants per each) containing sterilized substrate and kept under a controlled environment. The stems of the grown plants with 4-6 fully expanded leaves were inoculated with the laboratory-grown fungal culture, as mentioned before (9). The inoculated plants were left under observation to observe any vial symptoms development. The laboratory-grown fungal culture and the leaves of the inoculated plants with the virus and fungus were tested to detect the virus using RT-PCR.

## Results

### Virus identification using RT-PCR

The partial coat protein gene of specific amplification confirmed the presence of CMV. The expected bands of approximately 678 bps were successfully amplified from the leaves of the cucumber plants showing typical mosaic and yellowing that were collected from various plastic houses across different regions of Duhok Province of Kurdistan Region, Iraq, and screened for the presence of CMV infection through RT-PCR (Fig. 1a).

ISSN 2072-3857

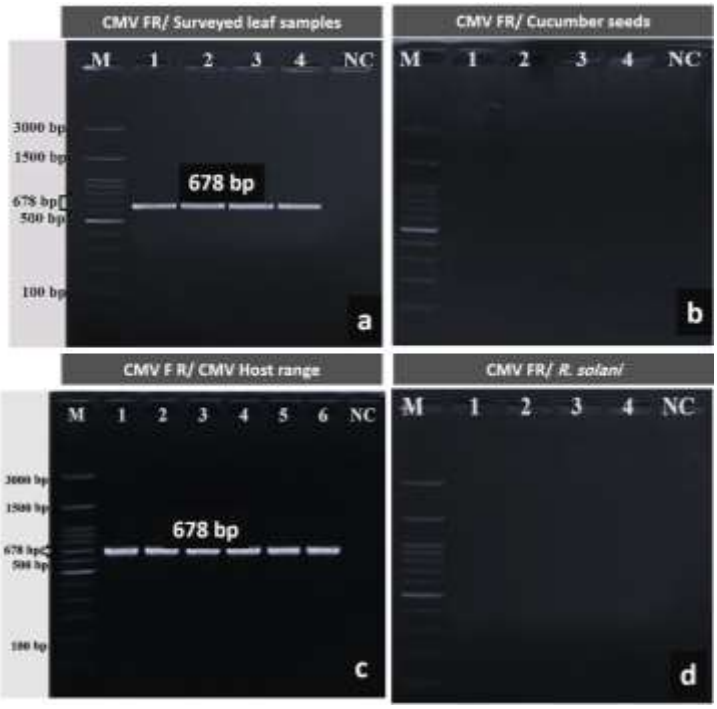



Figure (1): The RT-PCR products amplifications using primer pairs (CMV F and R) shown on agarose gel electrophoresis a) from the collected symptomatic cucumber leaves, b) cucumber seeds, c) CMV host plants, and d) the laboratory grown *R. solani* cultures where the first lane (M) is marker ladder (3000-100bp) and lanes 1-6 are the tested samples with a band size of 678 bps related to CMV presence or absence, and NC is negative control without band.

**Host Range**

The results revealed that the selected indicator plants C. *sativus, C. pepo, S. lycopersicum, C. annuum, N. tabacum,* and V. *unguiculata* were susceptible to CMV, as shown in Figures 2.3.4.5.6.7. These results show that the viral inoculation caused a systemic response in the tested plants as a result of CMV inoculation. The RT-PCR results showed that the cultured seeds of the various plant species used to determine the host range of the virus (Fig. 1b), so the symptoms observed on each were the result of virus inoculation. The appearance of the symptoms on the plants was 4–6 weeks post-inoculation, depending on the plant species.

Figure (2) displays the systemic symptoms, including severe yellowing, blistering, crinkling, malformation, necrosis, vein clearing, mosaic, mottling, leaf cupping, Stunting, vein banding, chlorosis of the leaf margin, flower abscission, as well as reduction of fruit production and lethal death on the inoculated *C. sativus*. Symptoms on the inoculated *C. pepo* leaves were shown as vein clearing, pale, bleached, or white areas on leaves, malformation, and mottling, as in Figure (3). On the inoculated *S. lycopersicum,* severe yellowing, mottling, necrosis, malformation, and stunting were appeared, as in Figure (4). Figure (5) shows the symptoms development on *C. annuum* leaves as malformation, stunting, and

ISSN 2072-3857

blistering. The inoculated *V. unguiculata* leaves showed mottling, severe yellowing, a darker green color along with mosaic patterns, and vein banding, as in Figure (5). At the same time, *C. quinoa* and *Z. elegans* did not respond to CMV inoculation and remained symptomless.

RT-PCR results confirmed that the appeared symptoms of each plant species were their response to mechanical transmission of CMV to them (Fig. 1 c). The results were similar to those of (4, 15, 19), who reported systemic infection of *C. sativus*, *C. pepo*, *S. lycopersicum*, *C. annuum*, *V. unguiculata*, and *N. tabacum* in response to CMV inoculation.




Figure (2): The developed symptoms *on C. sativus* leaves: healthy cucumber leaf (A), vein banding (B), crinkling, yellowing and necrosis (C), vein clearing (D), vein clearing, malformation and mosaic (E), mottling (F), leaf cupping (G), stunting (H), blistering (I) and yellow mosaic (J).

ISSN 2072-3857

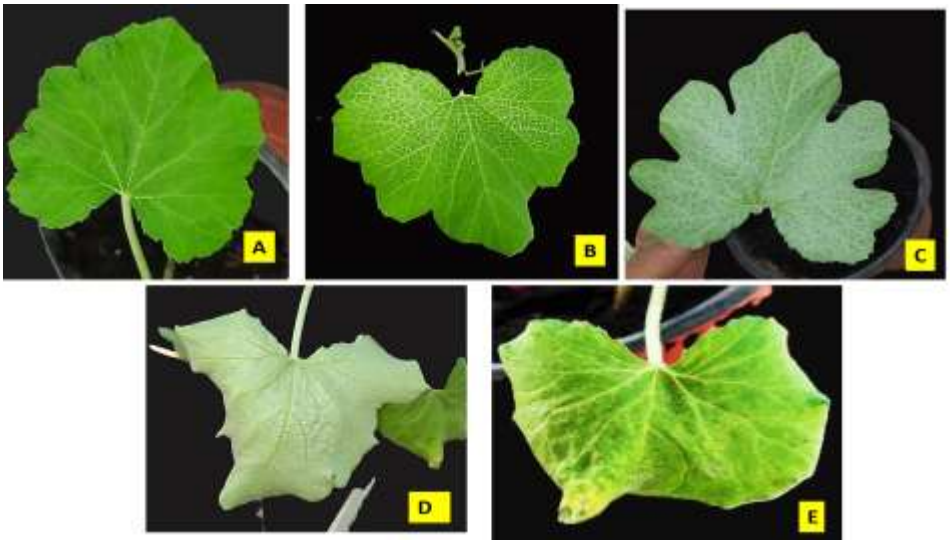



Figure (3): symptoms on (*C. pepo*) plant: healthy leaves (A), vein clearing (B), pale, bleached, or white areas on leaves(C). Malformation (D), mottling (E).

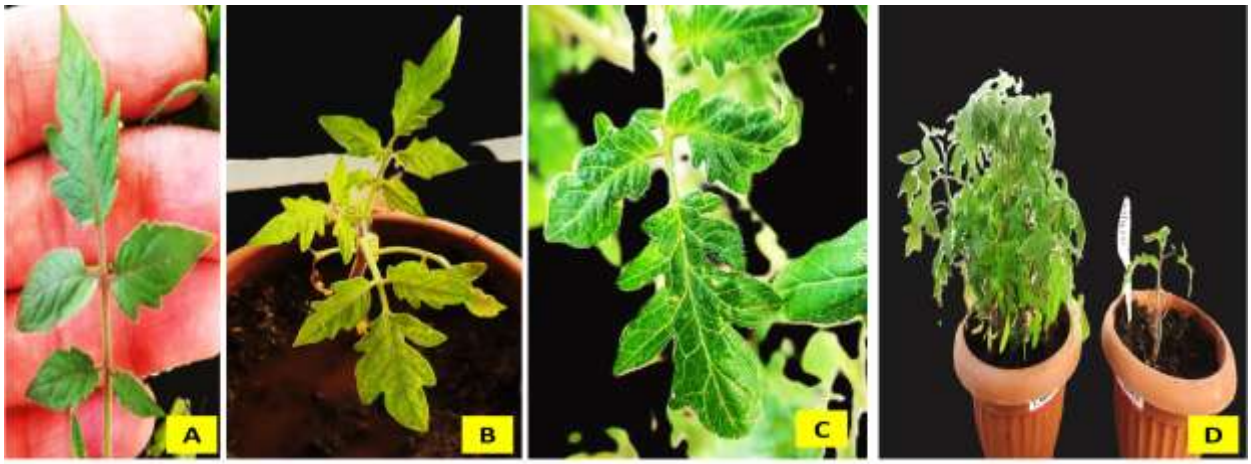



Figure (4): Symptoms of inoculated (S. *lycopersicum*) plant: healthy leaves (A), yellowing and mottling (B), malformation and necrosis (C), and severe stunting (D).

ISSN 2072-3857




Figure (5): Symptoms on (C. *annuum*) plant: healthy leaves (A), malformation (B), stunting (C). And blistering (D).




Figure (6): Symptoms of inoculation on (*N. tabacum*) plant: healthy leaves (A), chlorosis, malformation, and mottling (B), stunting (C). And vein clearing (D).




Figure (7): Symptoms *on (V. unguiculata*) leaves: healthy leaf (A), Leaves may develop a darker green color along with mosaic patterns of light and dark green (B), mottling (C), severe yellowing of leaves and vein banding (D)

ISSN 2072-3857

**CMV transmission by *R. solani***

Based on the results of RT-PCR, the *R. solani* cultures rise from the viral- and fungal-inoculated cucumber plants were subsequently CMV-free. In addition, *R. solani* does not play any role in CMV ؟؟؟؟؟ transmission from infected plants to healthy ones (Figure .1. d). The results disagree with those of (9), who found *R. solani could* acquire CMV during infection

**Discussion**

Although numerous viruses that may significantly reduce cucumber production have been identified globally, Cucumber plants may be infected by unidentified viral infections. The presence of CMV was confirmed by the RT-PCR results in the samples collected from various plastic houses in Duhok province.

The results of CMV host range showed that all of the tested plants, including *C. sativus, C. pepo, S. lycopersicum, C. annuum, N. tabacum, and V. unguiculata,* responded systemically to the viral infection. These plants' systemic response showed that they are the CMV host plants with the greatest reaction to the viral infection. While C. *quinoa* and *Z. elegans did* not respond to CMV inoculation and remained symptomless. The results of this research indicated that all tested species belonging to *Solanaceae, Fabaceae,* and Cucurbitaceae responded to the viral inoculation systemically., whereas the species of *Asteraceae* and *Chenopodiaceae* had not responded yet. Many plants from different families were shown to be susceptible to CMV, and the virus may have a larger host range than previously described.

In the current study, the author concluded that CMV could infect several vegetable crops and cause significant economic losses. CMV has been detected in various plastic houses of Duhok province using a molecular detection method. It has been reported that CMV causes local and systemic infections in cucumber, squash, melon, and watermelon (20, 21, 26). In their study in Iraq, CMV isolates were detected in cucumber and cowpea plants exhibiting mosaic, mottling, and leaf disorders in local fields in Baghdad province. Nowadays, PCR is one of the most reliable and accurate methods for detecting plant virus diseases. The studies are based on molecular detection of CMV. All previous research on CMV demonstrated that the isolated virus from cucumber has been shown to cause cowpea chlorotic lesions. (4).

Plant viruses and numerous mycoviruses have similar characteristics, especially with regard to their genome's coding methods and replication (10). Considering the high probability of a single plant being infected with both plant viruses and phytopathogenic fungi in the natural world, we expect that cross-infections between fungi and plant viruses may be more frequently observed than isolated infections.

**Conclusion**

CMV was detected on cucumber plants in Duhok province, Kurdistan region, and characterized by RT-PCR. This study also

ISSN 2072-3857

revealed that the presence of CMV can be described by its biological detection. *R. solani was* not detected in the infected plants by RT-PCR.

**Acknowledgment**
For logistical and technical support, the writers are thankful to Dr. Zulaykha A. Abduljalil from the Department of Plant Protection, University of Duhok. of the University of Duhok's Department of Plant Protection.

.

**Recommendation**

Further survey and continuous identification of CMV and other viruses in cucumber fields are needed. The application of RT-PCR as an efficient method for detecting CMV is highly recommended. Cultivation of certified seeds to produce healthy transplants important.

**References**

1. **Abduljalil ZA, Duhoky MMS, Kassim N (2019)** First record of Dahlia mosaic virus in Iraq on dahlia (*Dahlia pinnata).* The Journal of Duhok University. Section: Agriculture and Veterinary Science 22:113–120.
2. **Abduljalil**, Z. A. (2022). Molecular and biological characterizations of dahlia-infecting caulimoviruses in Iraq. Tropical Plant Pathology (2022) 47:591–598 https://doi.org/10.1007/s40858-022-00513-0.
3. **Adhab, M. & Al-Ani, R. (2011).** Amaryllis and Shrimp plant are secondary hosts of Cucumber mosaic virus (CMV) in Iraq. Agriculture and Biology Journal of North America 2(5): 872-875.
4. **Adhab, M.&Al-Ani, R. (2010).** Evaluation of SDS-Polyacrylamide gel electrophoresis and immunostrip technique for detection of Tobacco mosaic virus (TMV) and Cucumber mosaic virus (CMV) in Iraq. Arab Journal of Plant Protection 28(2): 181-189 (in Arabic).
5. **Al-Ani, R., Sabir, L., Adhab, M. & Hassan, A. 2009. R**esponse of some melon varieties to infection by Cucumber mosaic virus (CMV) under field conditions. The Iraqi Journal of Agricultural Sciences, 40 (6): 1-8. (in Arabic).
6. **Alfadhal, A.A. and Zagier, S.S.S. (2017).**Identification of Cucumber Mosaic Virus (CMV) on eggplant by using some of indicator plants , Immunostrip assay and reverse transcriptase-polymerase chain reaction (RT-PCR(. Kufa Journal for Agricultural Sciences. 107-92 (4)9.

ISSN 2072-3857

7. **Ali, A. K., Ahmed, I. A., Al-Kuwaiti, N. A. 2023.** Molecular of Cucumber Mosaic Virus Subgroup IB in Iraq. Plant Protection, 7(2), 289-294.
8. **AL-yasery, H., Fdhel, F.,&Alhatami, O. (2016).** Detection of Cucumber Mosaic Virus by Immunestrips and Reverse Transcriptase Polymerase Chain Reaction. Kufa Journal for Agricultural Sciences, 8(3): 221-239 (in Arabic).
9. **Andika I.; Wei, SH. Cao, CH.; Salaipetha, L.; Kondo, H; and Suna, L (2017).** Phytopathogenic fungus hosts a plant virus: A naturally occurring cross-kingdom viral infection. November 14, 2017 | vol. 114 | no. 46 | 12267–12272
10. **Bragard C, et al. (2013)**. Status and prospects of plant virus control through interference with vector transmission. Annu Rev Phytopathol 51:177–201.
11. **Das S, Falloon RE, Stewart A, Pitman AR (2014)** Molecular characterisation of an endornavirus from *Rhizoctonia solani* AG-3PT infecting potato. Fungal Biol 118:924–934.
12. **Daş, F. 2020**. Adana ve Mersin illeridomatesalanlarındahıyarmoza ikvirüsü (Cucumber mosaic virus, CMV) nünkarakterizasyonu. Çukurova Üniversitesi, Fen Bilimleri Enstitüsü, Yüksek Lisans Tezi, Adana.
13. **FAOSTAT**. Food and Agriculture Organization of the United Nations. (2025). Crop Production Data. Available online at FAO (base data), https://www.fao.org/faostat/en/#data/QCL. https://en.wikipedia.org/wiki/Cucumber?utm_source=chatgpt.com.
14. **Haji V.J., Abduljalil Z.A., and Kassim N.A. (2022**). Maize dwarf mosaic virus: a new causal agent inducing disease in rice plants of the fields of Kurdistan Region of Iraq. Tropical Plant Pathology. https://doi.org/10.1007/s40858-022-00535-8
15. **Kumari R, Bhardwaj P, Singh L, Zaidi AA, Hallan V. (2013)** Biological and Molecular Characterization of Cucumber Mosaic Virus Subgroup II Isolate Causing Severe Mosaic in Cucumber. Indian J. Virol. 2013; 24(1):27-34.
16. **Mackay, I. M. 2004.** Real-time PCR in the microbiology laboratory. Clinical microbiology and infection, 10(3): 190- 212.
17. **Mallick, P. K. (2022).** Evaluating Potential Importance of Cucumber (*Cucumis sativus* L. - *Cucurbitaceae*): A Brief Review. *International Journal of Applied Sciences and Biotechnology*, *10*(1), 12-15. https://doi.org/10.3126/ijasbt.v10i1.44152
18. **N. Rajinimala, E. Santhoshinii, R. Kannan, G. Ravi , K. Kavitha, J. Sheela (2024).** Transmission studies of Cucumber mosaic virus in Cucumber. Agriculture Association of Textile Chemical and Critical Reviews Journal (2024) 174-178.
19. **Nasir, A. A.,&Adhab, M. (2021).** A biologically distinct isolate of Cucumber mosaic virus from Iraq.


ISSN 2072-3857

In 2021, Third International Sustainability and Resilience Conference: Climate Change (pp. 148–150). IEEE. https://doi.org/10.1109/IEEECONF53624.2021.9668142

20. **Nogay, A., Yorgancı, Ü. 1984**. Investigations on the identification, seed transmission, and host range of viruses infecting the culture plants in the *Cucurbitaceae* in the Marmara region. 1. The identification of viruses infecting cucurbits in the Marmara region. Journal of Turkish Phytopathology, 13(1): 9
21. **Nogay, A., Yorgancı, Ü. 1985**. Investigations on the identification, seed transmission, and host range of viruses infecting the culture plants in the *Cucurbitaceae* in the Marmara region. 2- The seed transmissibilities and cucurbit hosts of CMV and WMV-2 isolated from the culture plants in the *Cucurbitaceae*. Journal of Turkish Phytopathology, 14(1): 9-16.
22. **Omar, B.,&Jasim, N. (2021).** Estimating the technical efficiency of the cucumber crop under different techniques: A translog stochastic frontier analysis. Russian Journal of Agricultural and Socio-Economic Sciences, 120(12), 164-178. https://doi.org/10.18551/rjoas.2021-12.17.
23. **Ouedraogo RS, Pita JS, Somda IP, Traore O, Roossinck MJ. 2019.** Impact of cultivated hosts on the recombination of Cucumber mosaic virus. J Virol 93:e01770-18. https://doi.org/10.1128/JVI.01770-18.
24. **Palukaitis, P., Roossinck, M., Dietzgen, R. & Francki, R. (1992).** Cucumber mosaic virus. Advances in virus research, 41: 281-348.
25. **Papan, A. N. 2022.**BandırmayöresindesalçalıkdomatesyetiştirilenalanlardaHıyarmozaikvirüsü (Cucumber mosaic virus, CMV)' nünsaptanmasıvekarakterizasyonu. Çukurova Üniversitesi, Fen Bilimleri Enstitüsü, Yüksek Lisans Tezi, 96s, Adana.
26. **Pratap, D., Kumar, S., & Raj, S. (2008).** First molecular identification of a CMV isolate causing shoestring symptoms on tomato in India. Australasian Plant Disease Notes, 3(1), 57-58.
27. **Revathy, K.A. and Bhat, A.I. (2017).** Complete genome sequencing of Cucumber mosaic virus from black pepper revealed a rare deletion in the methyltransferase domain of the 1a gene. Virus Disease, 28(3): 309-314.
28. **Salih, J. M.; Sido, A. S. (2025).** Morphological and Molecular Characterization of *Rhizoctonia solani* Isolates Causing Root Rot Disease of Chickpea. Zanin Journal of Science and Engineering, 1(3),37–47. https://doi.org/10.64362/zjse.84.
29. **Shabbir, M.A., Waleed, H.M.T., Anwar, U., Aykaç, A.B., Habiba, U., Aslam, H., Bilqees, I., Shafique, T., Shehzadi, L. & Fareed, M.A. (2025).** Cucumber

Mosaic Virus (CMV): Advances in Molecular Understanding, Disease Ecology and Management. Phytopathogenomics and Disease Control, 4(2), 213-222. [Received 26 Jul 2025; Accepted 11 Sep 2025; Published 27 Nov 2025].

30. **Sharma, S. 2023.** Domateste Cucumber mosaic virus (CMV)'un Biyolojik ve Moleküler Karakterizasyonu. Ege Üniversitesi, Fen Bilimleri Enstitüsü, Yüksek Lisans Tezi, İzmir.
31. **Soliman, A.M. (2019).** Identification of Cucumber Mosaic Virus Infecting Some Vegetable Crops in Saudi Arabia. J. of Virol. Sci., Vol. 6: 46- 54. ISSN: 2636-2937
32. **Valarmathi P, Kumar G, Robin S, Manonmani S, Dasgupta I, Rabindran R. 2016.** Evaluation of virus resistance and agronomic performance of rice cultivar ASD 16 after transfer of the transgene against Rice tungro bacilliform virus by backcross breeding. Virus Genes 52: 521-529. DOI: 10.1007/s11262-016-1318-x.
33. **Wagih,E. E.: Zalat, M. M. and Maha A. Kawanna, M. A. (2021).** Partial Characterisation of Two Isolates of Cucumber mosaic virus (CMV). Scientific Journal of Agricultural Sciences 3 (1): 144-157, 2021 Print (ISSN 2535-1796) / Online (ISSN 2535-180X). DOI: 10.21608/sjas.2021.52505.1064.
34. **Zheng L, Zhang M, Chen Q, Zhu M, Zhou E (2014).** A novel mycovirus closely related to viruses in the genus Alphapartitivirus confers hypovirulence in the phytopathogenic fungus Rhizoctonia solani. Virology 456-457:220–226.
35. **Zitter, T. A., Murphy, J. F. 2009.** Cucumber mosaic. The Plant Health Instructor. DOI: 10.1094/PHI-I-2009-0518- 01.

i