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Determination of Some Virus Diseases on Gerbera Plants in Antalya Province

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ABSTRACT

Gerbera spp., which is in the Asteraceae family, is the most widely cultivated cut flower ornamental plant in Türkiye after carnation. Approximately 74% of Türkiye's production is met from Antalya province. Virus diseases are a problem in the cultivation of *Gerbera* as they significantly reduce the yield and quality. In this study, which was carried out to detect some virus diseases seen in *Gerbera* production areas in Antalya province, surveys were carried out in commercial production areas in the 2021-2022 production season. For this purpose, a total of 112 leaf samples, which are thought to be infected with viruses, were collected from 100 *Gerbera* plants showing symptoms similar to virus disease symptoms and 12 selected weeds regardless of the presence of symptoms. These leaf samples, which were later brought to the laboratory, then were tested by the Double Antibody Sandwich Enzyme-linked Immunosorbent Assay (DAS-ELISA) method to detect infections of *Tomato spotted wilt virus* (TSWV), *Cucumber mosaic virus* (CMV), *Tobacco streak virus* (TSV) and *Impatiens necrotic spot virus* (INSV). As a result of the tests, TSWV (41.9%), CMV (1.7%) and TSV (37.5%) infections were detected in *Gerbera* plant samples. In addition, TSWV (25%) infections were most common in weed samples, followed by TSV (16%) and CMV (8.3%) infections. The presence of INSV virus was not detected in any of the leaf samples tested by DAS-ELISA. With this study, TSWV, TSV and CMV infections in *Gerbera* production areas in Türkiye were revealed for the first time.

1. Introduction

Gerbera is an ornamental plant belonging to the daisy family (Asteraceae). There are approximately 30 known species in nature. Gerbera has an important place in the production of ornamental plants in the world and in our country. According to 2020 data, world cut flowers and potted plants are produced on a total area of 749.200 ha. 77% (580.000 ha) of the world ornamental plants production areas are located in the Asia/Pacific region. The most important producers among Asian countries are China and India (Anonymous, 2021). In 2018, the most important exporting countries in the world are the Netherlands, Colombia and Germany, respectively. Türkiye ranks 25th among the world exporters (Anonymous, 2021).

According to the data of the Turkish Statistical Institute, the most produced cut flower types in 2019 were Carnation, Gerbera and Rose, respectively. In 2019, the Gerbera production area was 1 202 162 square meters and the Gerbera production for the same year was 134 481 050 pieces. For Antalya province, the production area is 905.000 square meters and the production amount is 100.040.000 pieces (TÜİK, 2021). Approximately 3/4 of Türkiye's production is met from Antalya province's Gerbera greenhouses.

Viral diseases, as well as fungal and bacterial diseases, significantly affect Gerbera production, leading to reduced yield and quality. There are many studies conducted in different parts of the world to determine the viral diseases of Gerbera. Kaminska (1993) investigated the presence of *Tomato spotted wilt virus* (TSWV), *Impatiens necrotic spot virus* (INSV) and *Chrysanthemum stem necrosis virus* (CSNV) by serological methods in Gerberas grown in greenhouses in Vranjska Banja, Serbia. As a result of the tests performed by the researcher, only TSWV was detected in the plant samples. This is the first report of TSWV in Serbia. Verma et al. (2004) conducted a serological study to determine virus infections in Gerbera production areas in India and found the presence of *Cucumber mosaic virus* (CMV) in plant samples. This study is the first report of CMV on Gerberas in India. Kondo et al. (2011) observed chlorotic spots and necrosis on chrysanthemums in Aomori Prefecture, Japan. Symptomatic plants were tested for *Cucumber mosaic virus*, *Tomato spotted wilt virus*,

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Impatiens necrotic spot virus and *Tobacco mosaic virus* by immune Strip. The results were positive for INSV and negative for CMV, TSWV and TMV. The presence of INSV on chrysanthemums was then confirmed by RT-PCR. This is the first report of INSV on chrysanthemums in Japan. There are some studies on TSV, which has not been diagnosed on Gerbera but has been diagnosed on some ornamental plants belonging to the Asteraceae family. Dijkstra (1983) investigated the presence of *Tobacco streak virus* (TSV) on a sunflower showing severe necrosis and chlorosis on the leaves. Serological tests proved the presence of TSV.

In the literature, only one study was found on the detection of virus diseases that are a problem in Gerbera production areas of Türkiye. In this study conducted by Türkoğlu and Fidan (1992), virus infections detected in carnations, gladiolus and Gerberas produced commercially in the Aegean Region were discussed. Possible viruses in these plants were transferred to test plants by mechanical inoculation method. Identification was made according to the symptoms and physical characteristics of these isolates on the test plants. With this study, the presence of *Tobacco mosaic virus* (TMV) and *Tobacco rattle virus* (TRV) infections in Gerberas was determined. Atay (2016) conducted a study on *Tobacco streak virus* (TSV) on *Helianthus annuus*, a field plant belonging to the Asteraceae family, to diagnose virus diseases in sunflowers in the Thrace Region. Samples of 244 plants and weeds thought to be infected were collected from production areas and subjected to serological tests. As a result of the tests, the presence of TSV was detected. This study is the first study in the Thrace Region where viral diseases on sunflower were determined. Since there are not enough studies on this subject in our country, this study was carried out to determine the presence of *Tomato spotted wilt virus* (TSWV), *Cucumber mosaic virus* (CMV), *Tobacco streak virus* (TSV) and *Impatiens necrotic spot virus* (INSV) which are likely to infect Gerbera plants.

TSWV is included in the Bunyaviridae family, *Tospovirus* genus (Tsompana, 2005; Şevik 2015). It is transmitted by thrips. The most important vectors are *Frankliniella occidentalis* and *Thrips tabaci* (Krisha-Kumar, 1993). In general, tanning, yellowing, mosaic, leaf curling, necrotic spots, necrotic lines and stunting are observed in plants. CMV is included in the genus *Cucumovirus* in the Bromoviridae family (Uzunoğulları and Gümüş, 2015). It is carried by infected plant sap and seeds of some hosts. There are more than 75 vectors of CMV, the most important and widespread of which are Cotton aphid (*Aphis gossypii*) and Green peach aphid (*Myzus persicae*) (Adkins 2000; Beşkeçili et al., 2021). In general, yellowing, stunting and narrowing of leaf lamina symptoms appear in plants infected with the virus in the early period. TSV is a virus species belonging to the *Ilarvirus* genus of the Bromoviridae family. The virus is transmitted into the plant and causes disease by pollen and thrips (Atay, 2016). The general symptom on the plant is necrotic and/or chlorotic ring spots on the leaf, especially near the veins. INSV is a virus agent belonging to the genus *Tospovirus* that can be transmitted by thrips (Şevik and Tohumcu, 2010). This virus, which has similar symptoms with TSWV, was initially known as a race of TSWV, but studies have revealed that it is a different species (Anonymous, 2020).

In this study, the presence of TSWV, CMV and TSV viruses, which constitute a problem in Gerbera production areas in Antalya province, was revealed for the first time as a result of serological tests. However, the presence of INSV was not detected in any plant samples tested.

2. Materials and Methods

2.1. Survey studies and collecting plant samples

In November 2021 and February 2022, within the scope of guided surveys carried out in the Gerbera production areas in Kepez district of Antalya province, Gerbera plants showing stunting and yellowing in the production area, chlorotic spots, ring spots and mosaic on the leaves, deformations in flowers, irregular formations of petals, damaged by acari, thrips and whiteflies, which play a role in the transmission of viral diseases, and leaf and flower samples collected from some weeds showing density inside and outside of the production area were the main materials for this study.

For this study, a total of 112 leaf samples were collected from 8 different production areas of approximately 50 decares in Kepez district during guided field surveys. The samples collected from the production areas were individually numbered with the place of collection, date, plant species and field size. The collected samples were stored in a deep freezer at -20 °C for serological studies.

2.2. Serological Assays

Double-antibody sandwich enzyme-linked immunosorbent assay (DAS-ELISA) test, which is one of the serological methods for the detection of possible infections of TSWV, CMV, TSV and INSV, was applied to Gerbera with symptoms similar to virus infections, as well as leaf and flower samples taken from weeds inside and outside the production area. For this purpose, DAS-ELISA tests were carried out by following the protocols recommended by the commercial company (Bioreba), which provided TSWV, CMV, TSV and INSV specific antibodies and positive controls. The tests were performed in a volume of 100 µl and in duplicate for each sample. For some Positive controls, extracts from known diseased plant samples were used. At the end of the ELISA tests, samples with absorbance values at least twice or more than the absorbance value read at 405 nm for the negative control in the ELISA reader were considered positive (Clark and Adams, 1977; Yeşil, 2021).

3. Results and Discussion

3.1. Collected Plant Samples in Field Studies

During the field surveys conducted in Kepez district of Antalya province between 2021 and 2022 production years, 100 plant and 12 weed samples were collected that were thought to be infected with TSWV, CMV, TSV and INSV viruses (Table 1.).

Table 1
Numbers and areas of the surveyed greenhouses and species and numbers of collected plant samples during survey studies in Kepez district.

Surveyed greenhouses	Area of the greenhouse (da)	Plant species	Number of samples
Greenhouse 1	4	*Gerbera* spp. *Senecio vernalis*	9 1
Greenhouse 2	6	*Gerbera* spp. *Malva sylvestris* *Senecio vernalis*	18 1 1
Greenhouse 3	4	*Gerbera* spp. *Senecio vulgaris*	9 1
Greenhouse 4	12	*Gerbera* spp. *Medicago sativa* *Malva sylvestris* *Urtica* sp.	18 1 1 1
Greenhouse 5	4	*Gerbera* spp. *Senecio vulgaris*	9 1
Greenhouse 6	9	*Gerbera* spp. *Medicago sativa*	14 1
Greenhouse 7	6	*Gerbera* spp. *Senecio vernalis* *Medicago sativa*	14 1 1
Greenhouse 8	5	*Gerbera* spp. *Malva sylvestris*	9 1
Total	50	*Gerbera* spp. Weeds	100 12

3.2. Observed Viral Symptoms on the Plants in the Surveyed Greenhouses

Viral symptoms such as stunting, general yellowing, discoloration of leaves, chlorotic spots, concentric ring spots, mosaic, chlorotic line on the pedicel, flower deformations and discoloration were observed in *Gerbera* plants during surveys in *Gerbera* production areas in Kepez district of Antalya province. In addition, thrips, acari and whitefly pests were observed in some parts of the production area.

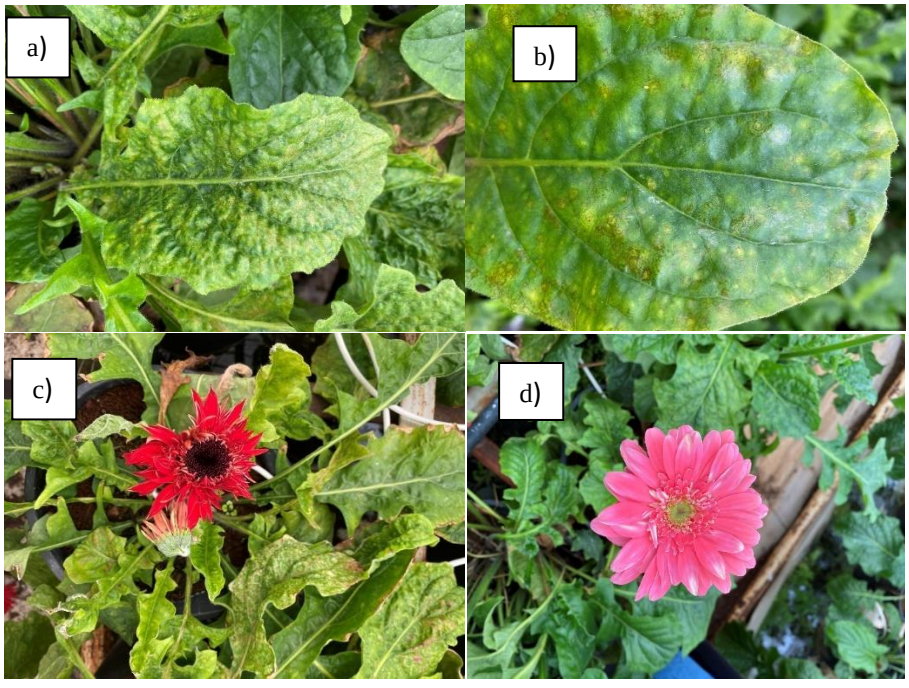

Figure 1
Common virus diseases symptoms on *Gerbera* plants. a) Chlorotic spots with puckering, b) Chlorotic and necrotic ring spots on leaves. c) Deformations on flower, d) Discolorations on petals.

Symptoms observed in the plant samples collected during survey studies vary according to the plant species, variety, age, developmental period (seedling, vegetative, flower), infection time, climatic conditions and virus species.

3.3. Results of DAS-ELISA Tests

Leaf and flower samples from a total of 112 plants, including 100 *Gerbera* plants showing viral disease symptoms and 12 weed samples showing density inside and outside the greenhouse, were collected from *Gerbera* production areas in Kepez district of Antalya province between 2021-2022, and DAS-ELISA test was applied to reveal the possible presence of TSWV, CMV, TSV and INSV viruses.

The disease rates of viral diseases seen in these plant samples were calculated separately for *Gerbera* plants and weeds (Table 2.).

Of the 100 *Gerbera* plants collected during surveys in the production areas, 44 were infected with TSWV and 40 with TSV; of the 12 weed samples, 5 were infected with TSWV, 2 with CMV and 1 with TSV. The presence of INSV virus was not detected in the collected samples. *Gerbera* plants in the production areas have a disease rate of 44% TSWV, 1% CMV, 40% TSV viruses. For the sampled weeds, this rate was calculated as 66.6% in *Medicago sativa*, 33.3% in *Malva sylvestris*, 100% in *Urtica* sp. and 50% in *Senecio vulgaris* (Tables 3 and 4).

Table 2
Relative incidences of the viruses according to DAS-ELISA tests.

Plant type	Number of tested samples	Nr. of infected samples (+)	Nr. of healthy samples (-)	Relative incidence (%)
Gerbera spp.	100	59	41	59
Weeds	12	5	7	41,6

Table 3
Relative incidences of TSWV, CMV, TSV and INSV on *Gerbera* spp. according to DAS-ELISA tests.

Virus	Nr. of infected samples (+)	Nr. of healthy samples (-)	Relative incidence (%)
TSWV	44	56	44
CMV	0	100	0
TSV	40	60	40
INSV	0	100	0

Table 4
Relative incidences of TSWV, CMV, TSV and INSV on the weed samples according to DAS-ELISA tests.

Weed species	TSWV	CMV	TSV	INSV	Number of samples	Nr. of healthy samples (-)	Relative incidence (%)
Medicago sativa	2	2	1	-	3	1	66.6
Malva sylvestris	1	-	-	-	3	2	33.3
Urtica sp.	1	-	-	-	1	0	100
Senecio vulgaris	1	-	1	-	2	1	50
Senecio vernalis	-	-	-	-	3	3	0

In this study, the presence of three different virus diseases that are a problem in *Gerbera* production areas in Kepez district was determined. Infections of TSWV, CMV and TSV viruses were detected as a result of testing of plant and weed samples collected from production areas with DAS-ELISA test.

Within the scope of this study, the rates of double (6.25%) and multiple (0.89%) virus infections were also determined as a result of DAS-ELISA test. When Table 4.5. is examined, it is seen that *Gerbera* plant samples were intensively infected with TSWV (44%) and TSV (40%) viruses. In some *Gerbera* spp. samples, TSWV+TSV double (5%) infections are present.

Double and multiple virus infections were also present in weed samples. There is TSWV+CMV double infection (33.3%) on *Medicago sativa* and TSWV+TSV double infection (50%) on *Senecio vulgaris*. TSWV+CMV+TSV multiple infections (33.3%) are observed on another example, *Medicago sativa*.

Table 5
Number of single, double and multiple infections in plant samples collected from *Gerbera* production areas of Antalya province according to plant species.

Surveyed greenhouse	Sample species	TSWV	CMV	TSV	INSV	TSWV + CMV	TSWV+TSV	TSWV+ CMV + TSV
Greenhouse 1	*Gerbera* spp.	1	-	3	-	-	-	-
	Senecio vernalis	-	-	-	-	-	-	-
Greenhouse 2	*Gerbera* spp.	13	-	-	-	-	5	-
	Malva sylvestris	-	-	-	-	-	-	-
	Senecio vernalis	-	-	-	-	-	-	-
Greenhouse 3	*Gerbera* spp.	3	-	1	-	-	-	-
	Senecio vulgaris	-	-	-	-	-	-	-
Greenhouse 4	*Gerbera* spp.	-	-	8	-	-	-	-
	Medicago sativa	-	-	-	-	-	-	1
	Malva sylvestris	1	-	-	-	-	-	-
	Urtica sp.	1	-	-	-	-	-	-
Greenhouse 5	*Gerbera* spp.	-	-	6	-	-	-	-
	Senecio vulgaris	-	-	-	-	-	1	-
Greenhouse 6	*Gerbera* spp.	-	-	8	-	-	-	-
	Medicago sativa	-	-	-	-	-	-	-
Greenhouse 7	*Gerbera* spp.	-	-	4	-	-	-	-
	Senecio vernalis	-	-	-	-	-	-	-
	Medicago sativa	-	-	-	-	1	-	-
Greenhouse 8	*Gerbera* spp.	1	-	1	-	-	-	-
	Malva sylvestris	-	-	-	-	-	-	-

There are not many studies on virus diseases that cause problems in *Gerbera* production areas in our country. However, there are similar studies investigating the presence of TSWV, CMV and TSV viruses for other crops.

In a study conducted on *Helianthus annuus*, a field plant belonging to the Asteraceae family in the Thrace Region, the presence of TSV was identified (Atay, 2016).

The presence of TSWV, DsMV (*Dasheen mosaic Potyvirus,* Potyviridae) and CMV diseases was investigated on some ornamental plants including *Gerbera* plants in Yalova, but TSWV and CMV viruses were not found on ornamental plants in the study (Kibar, 2014).

In a study conducted on bulbous ornamental plants in Çanakkale region, although virus or virus-like disease symptoms were observed in all samples, CMV virus was detected only in some of them. It is thought that the plant samples were infected with other viruses or virus-like diseases, either single or multiple (Karanfil et al., 2016). A study by Samuitiene and Navalinskiene (2008) on ornamental plants in Lithuania supports this view. In their study investigating CMV infections, they generally stated that virus and virus-like symptoms in ornamental plants are caused by a large number of viruses and virus-like diseases similar to each other.

In a study on viral diseases on *Gerbera jamesonii* in Greece, TSWV virus was identified, while INSV virus was not detected. Thrips populations were also noted in the observations made (Chatzivassilliou et al., 2000).

The most effective vectors of TSWV in Türkiye are *Frankliniella occidentalis* and *Thrips tabaci*, which play an active role in the spread of the disease (Tunç and Göçmen, 1995; Yeşil and Gömlekli, 2021). Similarly, thrips play an important role as a vector in the spread of TSV virus. In a study conducted on peanuts in India, it was determined that thrips were effective in the spread of TSV virus (Prasada Rao et al., 2003). A significant population of thrips was also observed in the production areas during survey studies. Considering all these, TSWV and TSV viruses can be easily spread in *Gerbera* production areas by thrips.

Weeds are an important factor in the spread of virus diseases. TSWV can infect 41 ornamental plants grown in greenhouses. In addition, many weed species are hosts of TSWV (Arli-Sokmen et al., 2005; Şevik 2015). In a study conducted by Costea et al. (2004), the presence of CMV virus was found to be the highest on weeds.

4. Conclusions and Recommendations

DAS-ELISA test, which is a serological method, was applied to the plant samples collected as a result of the survey studies. According to ELISA results, disease rates of 44% TSWV and 40% TSV were determined in 100 *Gerbera* spp. plants. INSV virus was not detected in the tested plant samples.

According to the results of the ELISA test on weed samples, the presence of TSWV, CMV and TSV were detected. The presence of INSV was also not detected on weeds. The disease rates of virus diseases on these weeds were calculated as 66.6% in *Medicago sativa*, 33.3% in *Malva sylvestris*, 100% in *Urtica* sp. and 50% in *Senecio vulgaris*. No virus was identified on *Senecio vernalis* leaf samples.

In addition, according to the ELISA test results, double and multiple infections were detected on the samples. TSWV+TSV double (5%) infection on 5 *Gerbera* spp. samples, TSWV+CMV double (33.3%) infection on 1 *Medicago sativa* sample, TSWV+TSV double

(50%) infection on 1 *Senecio vulgaris* sample, and TSWV+CMV+TSV multiple (33.3%) infection on 1 *M. sativa* sample were determined. Considering the presence of double and multiple infections in the ELISA test results and the fact that the collected samples showed virus and virus-like disease symptoms, it is thought that there are other virus diseases that have not been tested on the samples.

The fact that virus disease symptoms are commonly seen in some of the *Gerbera* greenhouses and that most of the producers do not have information about virus diseases is an issue that needs attention in terms of cut flower production and economy for Antalya province. Various training programs should be planned to inform producers about these virus diseases.

In some of the gerbera greenhouses, weeds were also commonly observed. Since weed species are hosts of virus diseases in addition to their direct damages, they cause these diseases to be seen in production areas in the following years. For this reason, weeds should be well identified and attention should be paid to weed control.

Effective insecticides should be used against vector insects, which are one of the most important factors in the spread of virus diseases, and quarantine measures should be taken against virus diseases that are not detected in the region, and production areas should be protected by preventing the transmission of virus diseases.

The data obtained as a result of the study will be the basic data for the future researches to be carried out in the region and will be a guide for both public institutions and organizations related to the subject and technical personnel working in the private sector and conscious producers.

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6. References

Anonymous (2020). Domates Hastalıkları- Tanısı, Biyolojisi ve Mücadelesi, Verda Yayıncılık, No;1-3, Ankara, 582-585, 609-613, 615.

Anonymous (2021). Orta Anadolu Süs Bitkileri ve Mamulleri İhracatçıları Birliği (2021). Dünya Süs Bitkileri Sektörü Araştırma Raporu. http://www.susbitkileri.org.tr/images/d/library/3eb447db-fcfc-4dd0-b1c6-64452d190e05.pdf (erişim tarihi:25.08.2022).

Adkins S (2000). *Tomato spotted wilt virus* positive steps towards negative success. *Molecular Plant Pathology*, 1 (3), 151-157.

Arli-Sokmen M, Mennan H, Sevik M, Ecevit O (2005). Occurrence of viruses in field-grown pepper crops and some of their reservoir weed hosts in Samsun, Turkey. *Phytoparasitica*, 33 (4), 347-358.

Atay HG (2016). Trakya bölgesi ayçiçeği üretim alanlarındaki virüs hastalıklarının saptanması üzerine araştırmalar (Master's thesis, Namık Kemal Üniversitesi).

Beşkeçili M, Güneş N, Gümüş M (2021). Antalya ili Demre ilçesi biber yetiştiriciliğinde Tomato spotted wilt virus (TSWV) ve Cucumber mosaic virus (CMV) etmenlerinin yaygınlığının belirlenmesi. *Ege Üniversitesi Ziraat Fakültesi Dergisi*, *58*(3), 399-405.

Chatzivassiliou EK, Livieratos I, Jenser G, Katis NI (2000). Ornamental plants and thrips populations associated with tomato spotted wilt virus in Greece. *Phytoparasitica*, *28*(3), 257-264.

Clark MF, Adams AN (1977). Charecteristic of microplatemethod of Enzyme-linked immuno sorbent assay for detection of plant viruses. *J. Gen. Virol*., 34: 475-483.

Costea M, Weaver SE, Tardif FJ. (2004). The biology of Canadian weeds. 130. Amaranthus retroflexus L., A. powellii S. Watson and A. hybridus L. *Canadian journal of plant science*, *84*(2), 631-668.

Dijkstra J (1983). *Tobacco streak virus* in sunflower (*Helianthus annuus*). *Netherlands Journal of Plant Pathology*, *89*(4), 153-169.

Kaminska M (1993). The response of Gerbera cultivars at different ages to tomato spotted wilt virus infection. *Phytopathologia Polonica*, *6*.

Karanfil A, Soylu B, Korkmaz S (2016). Investigation of cucumber mosaic virus infection by serological and molecular methods on ornamental bulbous plants in Canakkale province and its districts. *Trakya University Journal of Natural Sciences*, *17*(2), 105-110.

Kibar H (2014). Yalova ili kesme çiçek üretimi yapılan alanlarda *Tomato spotted wilt virus* (TSWV), *Dasheen mosaic virus* (DSMV) ve *Cucumber mosaic virus* (CMV)'lerinin saptanması üzerine araştırmalar (Master's thesis, Namık Kemal Üniversitesi).

Krisha Kumar, NK, Ullman DE, Cho JJ (1993). Evaluation of Lycopersicon germ plasm for tomato spotted wilt tospovirus resistance by mechanical and thrips transmission. *Plant disease*, *77*(9), 938-941.

Kondo T, Yamashita K, Sugiyama S (2011). First report of *Impatiens necrotic spot virus* infecting chrysanthemum (*Chrysanthemum morifolium)* in Japan. *Journal of general plant pathology*, *77*(4), 263-265.

Prasada Rao RDVJ, Reddy AS, Reddy SV, Thirumala-Devi K, Rao SC, Manoj Kumar V, Reddy DVR (2003). The host range of *Tobacco streak virus* in India and transmission by thrips. *Annals of Applied Biology*, *142*(3), 365-368.

Samuitienė M, Navalinskienė M (2008). Occurrence of Cucumber mosaic cucumovirus on ornamental plants in Lithuania. *Žemdirbystė Agriculture*, *95*(3), 135-143.

Şevik MA, Tohumcu EK (2010). Camgüzeli nekrotik leke virüsü (*Impatiens necrotic spot tospovirus*; INSV): özellikleri, konukçuları, belirtisi, yayılışı, coğrafi dağılımı ve mücadelesi. *Türk Bilimsel Derlemeler Dergisi*, (1), 29-34.

Şevik MA (2015). Sebze Üretimini Tehdit Eden Viral Hastalık Etmeni: Domates lekeli solgunluk virüsü (*Tomato spotted wilt virus*-TSWV). *Fen Bilimleri Enst. Dergisi Iğdır Univ. J. Inst. Sci. & Tech*, *5*(2), 17-23.

Tsompana M, Abad J, Purugganan M, Moyer J (2005). The molecular population genetics of the *Tomato spotted wilt virus* (TSWV) genome. *Molecular Ecology*, 14 (1), 53-66.

Tunç İ, Göçmen H (1995). Antalya'da bulunan iki sera zararlısı *Polyphagotarsonemus latus* (Banks) (Acarina, Tarsonemidae) ve *Frankliniella occidentalis* (Pergande) (Thysanoptera, Thripidae) üzerine notlar. *Türkiye Entomoloji Dergisi*, 19 (2), 101-109.

TÜİK (2021). Türkiye İstatistik Kurumu. Tarım istatistikleri. https://data.tuik.gov.tr/tr/ (Erişim tarihi:06.06.2022).

Türkoğlu T, Fidan Ü (1992). Ege Bölgesi'nde süs bitkilerinde görülen virüs hastalıkları: Karanfil, Glayöl ve Gerberalarda görülen virüs hastalıklarının tanıtılması. *Bitki Koruma Bülteni*, *32*(1-4), 19-26.

Uzunoğulları N, Gümüş M (2015). Marmara Bölgesi'nde bazı kültür bitkilerinde doğal enfeksiyona neden olan hıyar mozaik virüsü (*Cucumber mosaic virus*, CMV)'nün tespiti. *Trakya University Journal of Natural Sciences*, *16*(1), 9-15.

Verma N, Singh AK. Singh L, Kulshreshtha S, Raikhy, G, Hallan V, Zaidi AA (2004). Occurrence of *Cucumber mosaic virus* in *Gerbera jamesonii* in India. *Plant Disease*, *88*(10), 1161-1161.

Yeşil S (2021). Detection and molecular characterization of viruses infecting edible seed squash in Turkey. *Journal of Plant Diseases and Protection*, *128*(5), 1341-1355.

Yeşil S, Gömlekli Ö (2021). Determination of Prevalence and Reservoir Weed Species of *Tomato spotted wilt Tospovirus*-TSWV on Peppers Grown in Greenhouses in Kumluca District of Antalya, Türkiye. *Turkish Journal of Agriculture-Food Science and Technology*, *9*(sp), 2565-2570.