Open-Field Survey of Turkish Bottle Gourd Germplasm Reaction to Virus Diseases

Hakan Fidan[1], Nihal Denli[2], Halit Yetisir[3], Pelin K. Öztürk[4], and Çetin Nacar[2]

[1]*Akdeniz University, Faculty of Agriculture, Department of Plant Protection, Antalya, Turkey*
[2]*Alata Horticultural Research Station, Erdemli, Mersin, Turkey*
[3]*Erciyes University, Faculty of Agriculture, Department of Horticulture, Kayseri, Turkey*
[4]*Biological Control Research Institute Direction, Adana, Turkey*

e-mail: yetisir1@yahoo.com

Abstract. Grafting of vegetables, particularly watermelon, cucumber, and melon, has become widespread in Turkey. *Zucchini yellow mosaic virus* (ZYMV) is one of the most damaging diseases of cucurbit crops. The possibility of seed-transmission of ZYMV makes it an even more dangerous virus. Therefore, identification of potential sources of ZYMV resistance in bottle gourd is important. Resistant germplasm could be used for developing inbred lines as rootstocks for watermelon. The aim of this study was to screen Turkish bottle gourd genotypes for ZYMV, *Watermelon mosaic virus* (WMV), and *Cucumber mosaic virus* (CMV) resistance under open field conditions. Of the 324 accessions that were screened, 188 (55%) were found to be infected with ZYMV, 71 genotypes (21%) with WMV, and 40 (12%) with CMV, in single or mixed infections, and the rest of the accessions were virus-free. Seeds were collected from ZYMV-infected plants and sown. The seedlings were tested serologically and with RT-PCR techniques for presence of ZYMV, WMV, and CMV. We observed that ZYMV was transmitted by 3.19% of the seeds from obviously infected fruits. As a result of these observations, we have become convinced that bottle gourd rootstock germplasm needs to be resistant to ZYMV.

Keywords: Bottle gourd, virus, rootstock, germplasm

Introduction

Viruses are the most important pathogens of the cultivated Cucurbitaceae. More than 30 viruses causing destructive symptoms and considerable economic losses have been reported in cucurbit crops (Zitter et al. 1996, Yuki et al. 2000, Ko et al. 2007). *Zucchini yellow mosaic virus* (ZYMV), *Watermelon mosaic virus* (WMV), *Cucumber mosaic virus* (CMV), and *Papaya ring spot virus-W* (PRSV-W) are the most frequently encountered viruses in cucurbit crops in major cucurbit growing areas of the world (Unruean et al. 2013, Nontajak et al. unpublished). Their occurrence, spread, intensity of infection, and destructiveness depend on complex interrelations between the virus, its host plant, the vectors, and environmental conditions. It is usually not easy to find appropriate control measures to reduce the extent of destruction by viruses.

ZYMV, a member of the genus *Potyvirus* in the family Potyviridae, is one of the major viruses of cucurbits. Cultivars of *Cucurbita pepo* L., *Cucumis melo* L., and *Citrullus lanatus* (Thunb.) Matsum. & Nakai are particularly affected. However, other cucurbits, including bottle gourd, *Lagenaria siceraria* (Mol.) Standl., are also infected easily by ZYMV. Natural infection of bottle gourd by ZYMV has been observed in Hawaii (Ullman et al. 1991), India (Verma et al. 2004), Serbia (Dukić et al. 2006), U.S.A. (Provvidenti et al. 1984), and Turkey (Sertkaya et al. 2004, Fidan et al. 2013). In many cases, planting a disease-resistant cultivar is the best solution for controlling virus diseases in vegetable crops. Resistance to ZYMV in bottle gourd was reported in germplasm collected from several countries (Provvidenti 1977, 1995, Gerber 1978). However, only a limited number (18) of bottle gourd accessions have been tested for virus resistance (Provvidenti 1981).

The bottle gourd (*L. siceraria*) is one of the earliest domesticated plant species. Also known as calabash or white-flowered gourd, *L. siceraria* is an annual, a vigorous climber and monoecious. Geographic origin of this species is generally accepted as Africa (Whitaker 1971). Five perennial, dioecious, wild species of *Lagenaria*, *L. breviflora* (Benth.) Roberty, *L. abyssinica* (Hook. f.) C. Jeffrey, *L. rufa* (Gilg) C. Jeffrey, *L. sphaerica* E. Mey., and *L. guineensis* (G. Don) were reported from northern Africa (Decker-Walters et al. 2004). Two subspecies of *L. siceraria*, ssp. *asiatica* (Kob.) and ssp. *siceraria*, were described based on morphological characterization of vegetative

E.U. Kozik and H.S. Paris (Eds.): Proceedings of Cucurbitaceae 2016, the XIth EUCARPIA Meeting on Genetics and Breeding of Cucurbitaceae. July 24-28, 2016, Warsaw, Poland.

and generative plant organs (Heiser 1979). Bottle gourd is known for its growing ability with limited horticultural requirements and high adaptation capacity to different environmental conditions (Mladonović et al. 2012).

Bottle gourd has become also an impressive plant species with different shapes and sizes of fruits, allowing use of mature dry fruit for sundry purposes. Reported fruit shapes for bottle gourds are oblate, spherical, ovoid, pyriform, scoop-shape, club-shape, bilobal (proximal lobe is smaller), cylindrical, and elongated (Morimoto et al. 2005).

Bottle gourd is grown as a vegetable, the immature young fruits are eaten after being cooked (boiling, frying, or stuffing), like *Cucurbita pepo*, in Africa and Asia. In the southern part of the Turkey, bottle gourd fresh fruit is also consumed as vegetable like summer squash. The genotypes with non-bitter fruits are generally consumed as a vegetable, while the wild bitter varieties are preferred for the medicinal use or other uses. However, the mature fruits with dried hard shell are used in making several types of containers for storing or transferring liquids and kitchen stuff (scoop, cup, plate, etc.), musical instruments, decorations, or fishing floats (Yetisir et al. 2008, Loukou et al. 2011). Vegetative part of plants (leaves, shoots, and tendrils) are also used as vegetables by cooking and mixing with other vegetables and the seeds are removed for oil extraction. Leaves can be dried and stored to be used out-of-season (Grubben and Denton 2004). In western Africa, bottle gourd seeds, rich in oil (45%) and protein (35%), are used for making sauce and oil extraction for human consumption (Loukou et al. 2011). Seeds, tendrils, and young leaves are also used for some medical purposes (Herklots 1972, Moerman 1998, Manandhar 2002). The high adaptability of bottle gourd to different soil and growth conditions and resistance to some soil-borne diseases has made bottle gourd a suitable rootstock for watermelon. Bottle gourd is used as a rootstock for watermelon against soil-borne diseases such as Fusarium wilt (Oda 1995, Yetisir et al. 2003), low soil temperature (Lee 1994), salinity (Colla et al. 2005, Yetisir and Uygur 2010), excessive water in soil (Yetisir et al. 2006), and high pH (Colla et al. 2010). In eastern Asia (China, Japan, and Korea), *L. siceraria* has been widely used as a rootstock, particularly for watermelon, for many years. Recently, significant interest has been given to bottle gourd as a rootstock in Europe and in the U.S.A., as an alternative way to control soil-borne diseases such as Fusarium wilt (Miguel et al. 2004, Cohen et al. 2007).

Use of resistant varieties is a commonly accepted solution to manage virus diseases in vegetable crops. Therefore, determination of the current status of Turkish bottle gourd germplasm for resistance to important cucurbit viruses has primary importance. The objective of this study was to determine which viruses cause disease in bottle gourds and find accessions possessing resistance (without symptoms) under open-field and natural infection conditions.

Material & Methods

Plant material and experimental field

In this study, Turkish bottle gourd germplasm (324 accessions) was surveyed for ZYMV, WMV, and CMV under open-field conditions and natural infection. The plants were grown in a plot at the Alata Horticultural Research Institution in Mersin, Turkey. The site is located in the coastal area of the Mediterranean Sea (36°37' N; 34°20' F; altitude 5 m). Seedlings with 2 to 3 true leaves were transplanted to the field at 3 m distances between rows and 0.5 m within rows. Ten plants from each of 324 accessions were grown. Plants were watered by drip irrigation, fertilization at 100 kg N/ha, 100 kg P_2O_5/ha and 100 kg K_2O/ha was applied with drip irrigation during the growing period.

In each plot, plants were inspected and samples from plants showing virus-like symptoms were collected. Each sample consisted of the youngest fully developed leaf from plants exhibiting symptoms such as mosaic, mottle, chlorosis, vein clearing or yellowing of the foliage, and fruit discoloration and deformation. All samples (299) were tested for the presence of ZYMV, WMV, CMV, PRSV-W, CYSDV, CVYV, SqMV, CGMMV, and MNSV. All collected samples were placed in plastic bags stored at 4 °C and tested within 1 to 3 days for virus infection either serologically [double antibody sandwich enzyme-linked immunosorbent assay (DAS-ELISA)] or reverse transcriptase polymerase chain reaction (RT-PCR) (Table 1).

Table 1. Surveyed viruses and testing methods.

Virus name	Testing methods	Results
Cucumber mosaic virus (CMV)	ELISA	+
Zucchini yellow mosaic virus (ZYMV)	ELISA/RT-PCR	+
Watermelon mosaic virus (WMV)	ELISA	+
Squash mosaic virus (SqMV)	ELISA	-
Papaya ringspot virus (PRSV)	ELISA	-
Cucumber vein yellowing virus (CVYV)	RT-PCR	-
Cucumber green mottle mosaic virus (CGMMV)*	RT-PCR	-
Cucurbit aphid-borne yellows virus (CABYV)	RT-PCR	-
Cucurbit yellow stunting disorder virus (CYSDV)	RT-PCR	-
Melon necrotic spot virus (MNSV)	RT-PCR	-

*Not reported on cucurbit crops in Turkey.

Table 2. Primers used in RT-PCR and predicted amplicon size for major cucurbit virus diseases.

Primer	Sequence	Amplicon size bp
ZYMVF	ATGCTCCAATCAGGCACYC	791
ZYMVR	GTGTGCCGTTCAGTGTCTTC	
CVYVF	AGCTAGCGCGTATGGGGTGAC	450
CVYVR	GCGCCGCAAGTGCAAATAAAT	
CGMMVF*	TTGCGTTTAGTGCTTCTTATGT	440
CGMMVR*	GAGGTGGTAGCCTCTGACCAGA	
CABYVF	GAATACGGTCGCGGCTAGAAATC	600
CABYVR	CTATTTCGGGTTCTGGACCTGGC	
CYSDVF	AGTGACATGCCTAACTGTTACTT	364
CYSDVR	ATAGCTGCTGCAGATGGTTC	
MNSVF	CTCCATAAGCGCCAAGCAACC	485
MNSVR	AGCGGGGGAAAACAGAAGAA	

*Not reported on cucurbit crops in Turkey.

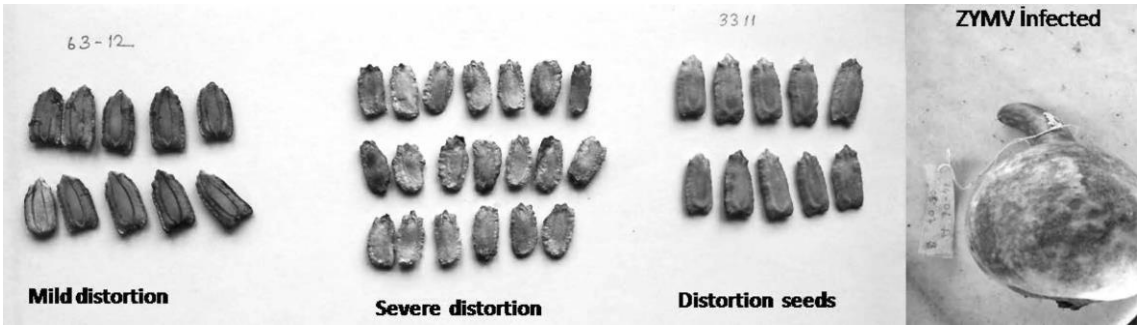


Figure 1. Distorted seeds harvested from infected bottle gourd plants.

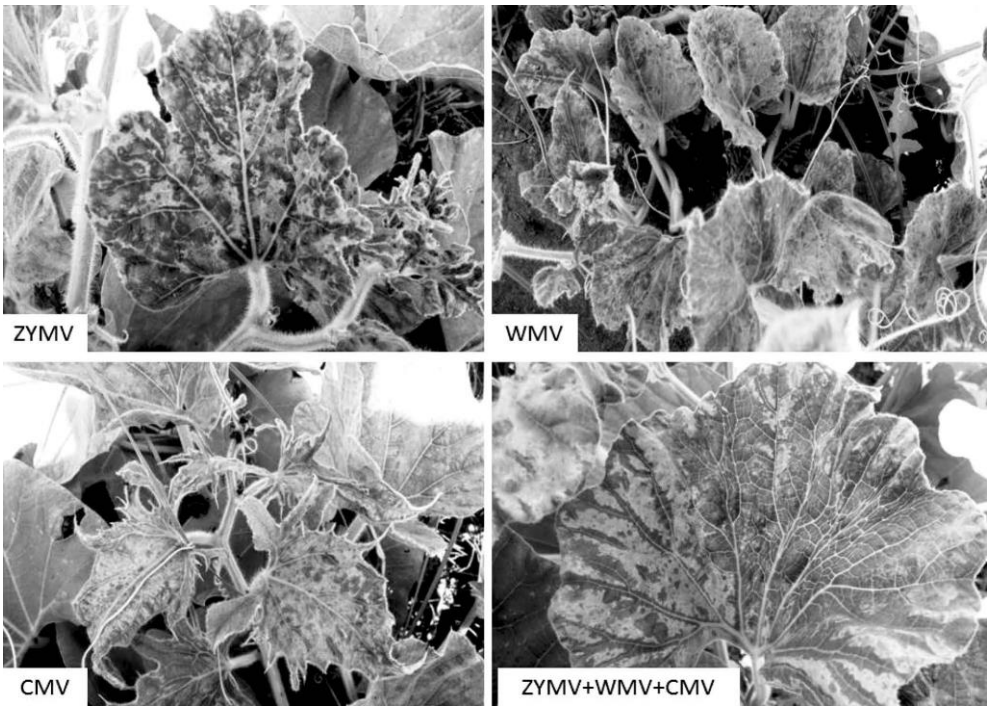


Figure 2. Leaf distortion, green mosaic (ZYMV), mosaic (WMV), and shoestring (CMV) symptoms in *Lagenaria siceraria* leaves caused by single or mixed infections by viruses.

Serological test

Serological assays were carried out using DAS-ELISA with polyclonal antibodies. Tests involved detection of viruses in infected young leaves and carried out according to Clark and Adams (1977). Polystyrene microtiter plates were coated with 1 : 1000 dilution of gamma globulin. The leaves of infected young plants were ground in the extraction buffer (phosphate buffered saline, PBS, pH 7.0). Plant samples were applied at a dilution of l : 5 (Wff) in PBS (pH 7.0), containing 0.05 volume Tween-20, 0.2% polyvinyl pyrolidone (PVP-40), and 2% bovine serum albumin (BSA). Plates were incubated at 4 °C overnight and washed four times. PBST Tween 20 buffer IgG-conjugate was applied at the concentration of 1 µl/1000 µl (Bioreba). Alkaline phosphatase conjugate was used at a 1/1000 dilution.

Results were acquired spectrophotometrically at 405 nm using a Medispec ESR 200 ELISA microplate reader. Also, against negative controls (healthy samples), twice the mean value and above, was considered positive. Positive controls of all viruses were supplied in lyophilized form with the kits and were resuspended in the sample buffer as recommended by the manufacturers (BIOREBA AG. Switzerland).

Total RNA isolation and reverse-transcription polymerase chain reaction (RT-PCR)

Total RNA extracts (Thermo Scientific GeneJETPlant RNA Purification Mini Kit) of virus-infected plants and seeds were used in a RT-PCR with sense and antisense primers. Primers used in this study and the expected length of each amplicon are presented in Table 2. First and second strand cDNAs were synthesized from RNA using Thermo Scientific Verso 1-Step RT-PCR Hot-Start Kit according to manufacturer's protocol. Amplification for each virus proceeded through a cycle of denaturation at 95 °C (45 s), annealing at 55 °C (1 min) and extension at 72 °C (1 min) for a total of 35 cycles in Techne Genius thermal cycler.

Table 3. Viruses found in open field survey and tested seeds from infected plants.

Virus name	Tested by	Infected plants	Infected seeds
Zucchini yellow mosaic virus (ZYMV)	ELISA/ RT-PCR	188 (55%)	8 (3.19%)
Watermelon mosaic virus (WMV)	ELISA	71 (21%)	--
Cucumber mosaic virus (CMV)	ELISA	40 (12%)	--
Papaya ring spot virus Type W (PRSV-W)	ELISA	0	--
Squash mosaic virus (SqMV)	ELISA	0	--
Cucurbit aphid-borne yellows virus (CABYV)	RT-PCR	0	--
Cucurbit yellow stunting disorder virus (CYSDV)	RT-PCR	0	--
Cucumber vein yellowing virus (CVYV)	RT-PCR	0	--
Cucumber green mottle mosaic virus (CGMMV)	RT-PCR	0	--
ZYMV+WMV	ELISA	23	--
ZYMV+CMV	ELISA	14	--
ZYMV+CMV+WMV	ELISA	11	--

Analysis of RT-PCR products

Ten µl of the PCR product was combined with gel loading buffer and analyzed on a 2% agarose gel containing 0.5 mg·ml^{-1} of ethidium bromide and photographed (Sambrook et al. 1989); 100 bp DNA ladder (Thermo) was used on each gel to determine the length of the amplified product.

Seed material and experimental conditions

Seeds were extracted from naturally ZYMV-infected fruits showing mild to severe symptoms and, after drying, were stored at 4 °C. The seeds were sown in an insect-proof greenhouse and the plants were visually observed. The plants with abnormal growth or virus symptoms were classified as severely distorted, distorted, and mildly distorted, and tested by ELISA techniques (Figure 1). In ELISA serological tests, Zucchini Yellow Mosaic Virus (Bioreba), Watermelon Mosaic Virus 2 (Bioreba), and Cucumber Mosaic Virus (Bioreba) kits were used. Others viruses were tested by the RT-PCR.

Results

A total of 299 *L. siceraria* leaf samples showing virus symptoms and seed samples harvested from infected plants were tested by ELISA and RT-PCR. Symptomological distinction of the viruses (ZYMV, WMV, PRSV, and CMV) is not easy (Figure 2). Therefore, we used ELISA and RT-PCR methods to determine which virus diseases were in the symptomatic plants.

The results showed that 188 genotypes (55%) were infected with ZYMV, 71 genotypes (21%) with WMV, 40 (12%) with CMV single or mixed infection and the rest (25 accessions) were virus-free (Table 3). Then the seeds were harvested from ZYMV-infected plants. Seeds were sown and seedlings were tested serologically using RT-PCR techniques for ZYMV,WMV, and CMV. The tests showed that ZYMV was transmissible by seeds at a frequencyof 3.19% in infected genotypes.

Discussion

The Cucurbitaceae are highly sensitive to virus infection. They are infected by more than 30 viruses, the most important being: CMV, WMV, ZYMV, PRSV, and *Squash mosaic comovirus* (SqMV) (Zitter et al. 1996). *Cucumber green mottle mosaic virus* (CGMMV) has not been reported on cucurbit crops in Turkey. Some of the bottle gourd accessions appear to be tolerant/resistant to ZYMV (Table 3). CYDSV, CABYV, PRSV, and SqMV have been reported in watermelon, melon, cucumber, and squash production fields in Turkey (Köklü and Yımaz 2006, Kaya and Erkan 2011).

Our results confirm the presence of ZYMV, WMV, and CMV in bottle gourd in our country. These viruses had been reported here previously at other localities (Sertkaya et al. 2004). ZYMV and WMV can be considered to be widespread. The most frequent virus, ZYMV, was present in 55% of the samples. This virus occurred in a relatively large number of samples (23) in combination with WMV. Compared with the other two viruses, CMV was detected only sporadically. As the symptoms caused by these three viruses in different bottle gourd accessions varied, it was not possible to establish a high correlation between the type of symptom and the virus. Therefore, field symptoms cannot be used as reliable indicators, even in the case when infection is caused by a single virus, due to complexity of the disease symptoms caused by many of the viruses. Also, in contrast with the results of other experiments with ZYMV that did not show transmission via seed, our study indicated seed transmission in bottle gourd. Seed-transmitted diseases, viral, bacterial, and fungal, are most significant in grafted transplant production. Because one single contaminated seedling (rootstock or scion) can easily contaminate several others during the grafting process and eventually the entire production field. Hence, identification of virus-resistant genotypes of bottle gourd will be important for further watermelon rootstock breeding programs.

Conclusion

Infection of bottle gourd with ZYMV, WMV, and CMV was observed in bottle gourd accessions. While the majority of bottle gourd accessions were infected by a single virus or mixture of viruses, some accessions were symptom-free. ZYMV was observed to be transmitted in bottle gourd seeds at the level of 2.5%. As grafting of watermelon on bottle gourd becomes more common, breeding virus-resistant bottle gourd rootstocks will become extremely important. Future research needs to continue to focus on the evaluation of bottle gourd germplasm for cucurbit virus resistance, particularly the seed-transmittable viruses.

Literature Cited

Clark MF, Adams AN (1977) Characteristics of microplate method of enzyme- linked immunosorbent assay for the detection of plant viruses. J Gen Virol 342: 475–483.

Cohen R, Burger Y, Horev C, Koren A, Edelstein M (2007) Introducing grafted cucurbits to modern agriculture: the Israeli experience. Plant Dis 91: 916–923.

Colla G, Rouphael Y, Cardarelli M, Salerno A, Rea E (2010) The effectiveness of grafting to improve alkalinity tolerance in watermelon. Environ Exp Bot 68: 283–291.

Colla G, Fanasca S, Cardarelli M, et al. (2005) Evaluation of salt tolerance in rootstocks of Cucurbitaceae. In: Gavilan MU (ed) Proceedings of International Symposium on Soilless Culture and Hydroponics 2004. Acta Hort 697: 469–474.

Decker-Walters DS, Wilkins-Ellert M, Chung S, Staub JE (2004) Discovery and genetic assessment of wild bottle gourd [*Lagenaria siceraria*; (Mol.) Standley; Cucurbitaceae] from Zimbabwe. Econ Bot 58: 501–508.

Dukić N, Krstić B, Vico I, Berenji J, Duduk B (2006) First report of *Zucchini yellow mosaic virus*, *Watermelon mosaic virus*, and *Cucumber mosaic virus* in bottle gourd (*Lagenaria siceraria*) in Serbia. Plant Dis 90: 380.

Fidan H, Denli N, Ozturk PK, Nacar N, Yetisir H (2013) Current situation of gourd germplasm against virus diseases in Turkey. In: Perez Alfocea F (ed) 1st Annual Conference COST ACTION FA 1204 – ROOTOPOWER. Workshop Book of Abstracts, Murcia, Spain, p 18.

Gerber RS (1978) *Watermelon mosaic virus* 1 and 2 in Queensland cucurbit crops. Australian J Agr Res 29: 1235–1245.

Grubben GJH, Denton OA (2004) Plant resources of tropical Africa 2. Vegetables. Wageningen: PROTA Foundation Backhuys Publishers.

Herklots GAC (1972) Vegetables in South East Asia. London: George Allen and Unwin.

Hesier CB (1979) The gourd book: a thorough and fascinating account of gourds from throughout the world. Norman: University of Oklahoma Press.

Kaya A, Erkan S (2011) İzmir, Aydın, Manisa ve Balıkesir İllerinde üretilen kabakgillerdeki viral etmenlerin tanılanması ve yaygınlıklarının belirlenmesi. Bitki Koruma Bülteni 51: 387–405.

Ko SJ, Lee YH, Cho MS, et al. (2007) The incidence of virus diseases on melon in Jeonnam province during 2000–2002. Plant Pathol J 23: 215–218.

Köklü G, Yılmaz Ö (2006). Occurrence of cucurbit viruses on field-grown melon and watermelon in the Thrace Region of Turkey. Phytoprotection 87: 123–130.

Lee JM (1994) Cultivation of grafted vegetables I. Curent status, grafting methods and benefits HortScience 29: 235–239.

Loukou AL, Lognay G, Barthelemy JP, Maesen P, Baudoin JP, Zoro BI (2011) Effect of harvest time on seed oil and protein contents and compositions in the oleaginous gourd *Lagenaria siceraria* (Molina) Standl. J Sci Food Agr 91: 2073–2080.

Manandhar NP (2002) Plants and people of Nepal. Portland, OR: Timber Press.

Miguel A, Maroto JV, San Bautista A, et al. (2004) The grafting of triploid watermelon is an advantageous alternative to soil fumigation by methyl bromide for control of fusarium wilt. Sci Hortic. 103: 9–17.

Mladonović E, Berenji J, Ognjanov V, Ljubojević M, Čukanović J (2012) Genetic variability of bottle gourd *Lagenaria siceraria* (Mol.) Standley and its morphological characterization by multivariate analysis. Arch Biol Sci 64: 573–583.

Moerman D (1998) Native American ethnobotany. Portland, OR: Timber Press.

Morimoto Y, Maundu P, Fujimaki H, Morishima H (2005) Diversity of landraces of the white flowered gourd (*Lagenaria siceraria*) and its wild relatives in Kenya: fruit and seed morphology. Genet Resour Crop Evol 52: 737–747.

Oda M (1995) New grafting methods for fruit-bearing vegetables in Japan. JARQ 29: 187–198.

Provvidenti R (1977) Evaluation of vegetable introductions from the People's Republic of China for resistance to viral diseases. Plant Dis Rep 61: 851–855.

Provvidenti R (1981) Sources of resistance to viruses in *Lagenaria siceraria*. Cucurbit Genet Coop Rep 4: 38–40.

Provvidenti R (1995) A multi-viral resistant cultivar of bottle gourd (*Lagenaria siceraria* from Taiwan). Cucurbit Genet Coop Rep 18: 65–67.

Provvidenti R, Gonsalves D, Humayden HS (1984) Occurrence of *Zucchini yellow mosaic virus* in cucurbits from Connecticut, New York, Florida, and California. Plant Dis 68: 443–446.

Sertkaya G, Sertkaya E, Yetişir H, Kaya K (2004) Hatay Ilinde Yetiştirilen Kabaklarda *Zucchini Yellow Mosaic Potyvirus* (Zymv)'ünYaygınlığınınveTaşınmasınınAraştırılması, Türkiye I. BitkiKoruma Kongresi Bildirileri, Samsum, Turkey, 8-10 Eylül 2004 , cilt 1, no 1.

Sambrook J, Fritsch EF, Maniatis T (1989) Molecular cloning: a laboratory manual. New York, Cold Spring Harbor Laboratory.

Ullman DE, Cho J, German TL (1991) Occurrence and distribution of cucurbit viruses in the Hawaiian Islands. Plant Dis 75: 367–370.

Unruean P, Lertrat K, Thummabenjapone P (2013) Evaluation the stability of CGMMV resistant phenotype in cucumber lines S2 and S3 generations served from commercial varieties and tentative inbred lines resistant to CGMMV. KhonKaen Agric J 41 suppl 1: 199–204.

Verma R, Ahlawat YS, Tomer SPS, Prakash S, Pant RP (2004) First report of *Zucchini yellow mosaic virus* in bottle gourd (*Lagenaria siceraria*) in India. Plant Dis 88: 426.

Whitaker TW (1971) Endemism and pre-Columbian migration of bottle gourd, *Lagenaria siceraria* (Mol.) Standl. In: Riley CL, Kelley JC, Pennington CW, Runds RL (eds) Man across the sea. University of Texas Press, Austin, pp 78–218.

Yetisir H, Caliskan ME, Soylu S, Sakar M (2006) Some physiological and growth responses of watermelon [*Citrullus lanatus* (Thunb.) Matsum. and Nakai] grafted onto *Lagenaria siceraria* to flooding. Environ Exp Bot 58: 1–8.

Yetisir H, Sakar M, Serce S (2008) Collection and morphological characterization of *Lagenaria siceraria* germplasm from the Mediterranean region of Turkey. Genet Resour Crop Evol 55: 1257–1266.

Yetisir H, Sari N, Yücel S (2003) Rootstock resistance to Fusarium wilt and effect on watermelon fruit yield and quality. Phytoparasitica 31: 163–169.

Yetisir H, Uygur V (2010) Responses of grafted watermelon onto different gourd species to salinity stress. J Plant Nutr 33: 315–327.

Yuki VA, Rezende JAM, Kitajima EW, et al. (2000) Occurrence, distribution, and relative incidence of five viruses infecting cucurbits in the state of Sao Paulo, Brazil. Plant Dis 84: 516–520.

Zitter TA, Hopkins DL, Thomas CE (1996) Compendium of Cucurbit Diseases. St. Paul, MN: APS Press.