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Vegetable Bacterial Diseases in Turkey

Kubilay Kurtulus Bastas

Department of Plant Protection, Faculty of Agriculture, Selcuk University, Campus/Konya, Turkey

Corresponding author: * **kbastas@selcuk.edu.tr, kbastas1@hotmail.com**

ABSTRACT

Turkey ranks fourth in world vegetable production while production of many vegetables is in the top three. In the last two decades, bacterial disease agents were determined by different identification (biochemical, physiological, morphological, serological and molecular) in some vegetables and seeds. In the major vegetable production regions, bacterial pathogens have been isolated from tomato, bean, mushroom, cauliflower, cabbage, broccoli, Brussels sprouts, lettuce, potato, pepper, pea, carrot and cucurbits. It was possible to protect from and prevent diseases through phytosanitary measures, good agricultural practices and good manufacturing practices during cultivation, harvest, storage, transport, and marketing. In some studies, for disease management, reactions of plant varieties were studied against bacterial pathogens, and promising varieties were obtained. Classic, physical and chemical applications, systemic acquired resistance (SAR) inducers, plant extracts and essential oils also have been successful at different levels for bacterial diseases. Plant growth-promoting rhizobacteria (PGPR) were isolated from the rhizosphere and phyllosphere of these related plants, and those bacteria showed successful results in both preventing disease and plant growth. Biological control agents like Pseudomonads and *Bacillus* spp. were used for controlling vegetable bacterial diseases. These databases of vegetable bacterial disease in Turkey are important, and epidemics and major economic losses can be successfully prevented by applying different control methods.

Keywords: bacteria, control, identification, seed, vegetable

CONTENTS

INTRODUCTION

Vegetables are essential and increasingly popular component of human nutrition and diets today. Collectively, vegetable crops are a major part of agricultural commerce. Vegetable production and marketing in the 21st Century has been fashioned by technology and developments that are unique to our times, including molecular biology, globalization of international trade, awareness of the benefits and dangers of synthetic pesticides, and insights into specific health benefits of vegetable foods. Consumer standards and market requirements cause excellent quality produce. The diseases that affect vegetables compromise such quality and therefore are of great importance to grower, shipper, marketer, and consumer.

The seed sector has been increasingly important in Turkey. The hybrid vegetable seed causes to lose large amount of foreign exchange in seed import. While vegetable varieties grown in greenhouse have been hybrid varieties recently, the use of hybrid varieties also increases fast in field production. In 2002 and 2007, the certified vegetable seed production and the imported vegetable seed reached from 1.249 tons to 2.731 tons and from 1.148 tons to 1.620 tons, respectively. In 2007, the value of vegetable seed was 57% of total imported seed and 16% of total exported seed (Ozalp *et al*. 2008).

Seed-borne vegetable bacterial pathogens cause high damages on yield and seed quality on plants. The first strategy to use for controlling any disease is to eliminate or reduce the amount of the pathogen available to initiate disease.

Turkey ranks 4th in the world after China, India and USA for vegetable production with 25.6 million tones and has a 3.1% share (Yucel *et al*. 2008). Tomato, melon and watermelon are the most common vegetables with a large cultivation area in Turkey. Bacterial diseases of vegetables are some of the most serious and destructive diseases affecting both field and greenhouse grown crops. Under moist field conditions they cause localized epidemics affecting young developing fruit; in the greenhouse total crop losses occur in Turkey.

In this review, the results of the scientific studies can be accessed were summarized about the vegetable bacterial disease and their control methods in Turkey for the last two decades.

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Invited Review

TOMATO BACTERIAL DISEASES

Tomato (*Lycopersicum esculentum* Mill.) is one of the most important greenhouse and field-grown vegetables in Turkey, with a production of 10.745.600 tons in 2009 (FAO 2011). Major fresh market tomato production takes place in the Aegean, Mediterranean and Marmara regions. Tomato is an important fresh fruit in Turkey's export, and ranks third after citrus and stone fruits with a 14% share (Yucel *et al*. 2008).

Some pests and diseases cause important yield loses in greenhouses and field grown tomatoes. The bacterial diseases include bacterial canker (*Clavibacter michiganensis* subsp. *michiganensis*), bacterial spot (*Xanthomonas axonopodis* pv. *vesicatoria*), bacterial wilt (*Ralstonia solanacearum*), bacterial speck (*Pseudomonas syringae* pv. *tomat*o), bacterial stem rot (*Erwinia* spp.) and tomato pith necrosis (*Pseudomonas corrugata*, *Pseudomonas viridiflava*, *Pseudomonas cichorii*, *Pseudomonas mediterranea*, *Pseudomonas fluorescens*) and soft rot bacteria (*Pectobacterium carotovorum* subsp. *carotovorum* and *Pectobacterium carotovorum* subsp. *atrosepticum*, *Pectobacterium chrysanthemi*). All these species except *P. c.* subsp. *atrosepticum* have been reported as causal agents of the disease in many commercial greenhouses in Aegean and Mediterranean Regions of Turkey since early 1990s (Demir 1990; Cınar and Aysan 1995; Aysan 2001; Ustun and Saygili 2001a; Sahin *et al*. 2002; Basim *et al*. 2004; Sahin *et al*. 2004; Saygili *et al*. 2004; Basim *et al*. 2005; Sahin *et al*. 2005; Aysan *et al*. 2006), but the most widespread species have been *P. viridiflava*, *P. cichorii* and *P. c.* subsp. *carotovorum* (Ustun and Saygili 2001; Aysan *et al*. 2005; Ustun *et al*. 2007).

Four semi-selective agar media (D2an, SCM, mSCM and KBT) were evaluated for the recovery and visible colony forming time of *C. m.* subsp. *michiganensis* and the selectivity of unidentified bacterial isolates from tomato seed and plants. Recovery of *C. m.* subsp. *michiganensis* on D2an, SCM, mSCM and KBT in comparison to Nutrient Dextrose Agar (NDA) medium ranged from 97.3, 20.0, 107.0 and 64.0%, respectively. Percent reduction of unidentified bacteria was 36.4% on D2an, 27% on SCM, 63.6% on mSCM and 9.1% on KBT (Ozyılmaz and Benlioglu 2001).

Selected strains of nonpathogenic fluorescent Pseudomonads and *Bacillus* spp. from rhizoplane of various plants were examined in a greenhouse pot tests for their ability to reduce bacterial speck disease severity caused by *P. s.* pv. *tomato*. Some Rhizobacteria strains applied to roots of seedlings reduced the disease severity by 65-80%. It was determined that these strains of Rhizobacteria triggered an induced systemic resistance (ISR) response against infection by the bacterial speck pathogen (Ozaktan *et al*. 2001).

Survival places except vegetation period (seed, soil and plant debris) longevity of the life period on seed, ability of the infected seeds in occurring new infestations and roles on them in first infections of *P. c.* subsp. *carotovorum* and *P. chrysanthemi* the causal agent of tomato stem necrosis were investigated. It was found that the pathogens could not survive in soil but they could survive in infected plant debris and seeds and serve as first inoculums resource wilted plants from contaminated seeds of diseased fruits showed us that these pathogens are seedborne (Yildiz *et al*. 2001a).

Effects of plant extract and volatile oils (eucalyptus, garlic and thyme) and compost extracts (weed and cow manure composts) on tomato stem necrosis pathogens *P. viridiflava*, *P. chrysanthemi* and *P. c.* subsp. *carotovorum* were studied *in vitro* and on potato slices experiments. In the studies two different sterilization methods (filtration and autoclaving) and 3 different concentrations (50, 40 and 30%) of the extracts were used. Filtered and autoclaved eucalyptus extract and filtered garlic extract in 50% concentration were effective against all pathogens. Weed and manure compost extracts were not effective for all pathogens (Yildiz *et al*. 2001b).

Ustun and Demir (2001) determined reactions of 21 tomato cultivars to *P. corrugata*, *P. viridiflava* and *P. cichorii* causing tomato pith necrosis. Invictus, Platina, Duygu, Shasta, Sun 6109 and Newton F18402 were found moderately resistant to *P. corrugata*, *P. viridiflava* and *P. cichorii*, respectively.

In four separate greenhouse experiments, one month old tomato plants grown inpots were artificially inoculated with *P. cichorii*, *P. viridiflava* and *P. c.* subsp. *carotovorum*. Nitrogen applied as nitrate and ammonium at 0, 150, 300 and 450 ppm levels affected the plant growth with some phytotoxic effect at high levels. All nitrate and 150 ppm ammonium nitrogen levels increased *P. viridiflava* and *P. c.* subsp. *carotovorum* infections, but 300 and 450 ppm ammonium levels had no effect on disease development. Nitrogen treatments, except 150 ppm nitrate nitrogen, decreased disease severity of *P. cichorii*. Potassium applications (0, 200, 400 and 600 ppm) reduced disease incidence and there was negative correlation between disease development and potassium levels. High relative humidity increased the length of necrosis, caused by *P. cichorii*, *P. viridiflava* and *P. c.* subsp. *carotovorum* at the rate of 22.17, 23.33 and 42.59%, respectively. High relative humidity in combination with low night temperature increased disease severity caused by *P. cichorii* and *P. c.* subsp. *carotovorum*, but had no effect on *P. viridiflava* infection. Nitrogen level, causing highest disease severity, potassium deficiency, high relative humidity and low night temperature in combination increased length of necrosis by *P. cichorii*, *P. viridiflava* and *P. c.* subsp. *carotovorum* 53.89%, 54.65% and 48.99%, respectively (Ustun and Saygılı 2002).

Antagonistic activities of 20 isolates including bacteria and yeast were determined against *P. corrugata* and *P. cichorii* by Ulke *et al*. (2002). Eleven isolates against *P. corrugata*, 1 isolate against *P. cichorii* showed inhibition zone on medium agar. In addition, effects of 7 isolates randomly selected for each pathogen among 20 candidate antagonists, were tested for growth of pith necrosis pathogen on inoculated tomato seeds on medium agar. 4 antagonists out of 7 against *P. corrugata*, 2 out of 7 antagonists against *P. cichorii* were found to be effective that ranged from 90-100% ratios.

ISR 2000 and consecutive application of ISR 2000 and CropSet reduced *C. m.* subsp. *michiganensis* incidence significantly from 87% (water control) to 44% and 42% and the severity index from 4.37 (water control) to 2.45 and 2.56, respectively. The incidence (80%) and severity index (4.55) in Messenger treated plots was not significantly different from these in water control plots (Ustun *et al*. 2009a). Also Acibenzolar-S-methyl induced resistance in tomato seedlings against *C. m.* subsp. *michiganensis* (Soylu *et al*. 2003).

Possibilities of biological control were investigated by the use of some antagonists for controlling *P. chrysanthemi*. Seventy-one candidate antagonists were isolated from tomato rhizosphere in Adana and Mersin provinces in Turkey Eight out of 13 selected isolates reduced the disease development between 89 and 33%. One of the antagonists provided a good level (74% protection) on tomato plants against *P. chrysanthemi* in the greenhouse experiments. The present study is the first report on the efficiency of potential biocontrol agents against tomato bacterial pathogens in Turkey (Aysan *et al*. 2003a).

X. a. pv. *vesicatoria*, *P. corrugata* and *C. m.* subsp. *michiganensis* were detected from tomato plant tissue and seeds by amplification of 355 bp (*hrp* gene), 1100 bp and 614 bp (pat gene) DNA fragments using multiplex Bio-PCR technique. The fast detection and identification of the different bacterial pathogens in a single tube by Polymerase Chain Reaction (PCR) maybe useful for both research and quarantine works (Basim and Basim 2004).

Aysan *et al*. (2004a) developed a *P. viridiflava*-specific polyclonal antibody which reacts positively with all references and strains of *P. viridiflava*, without having any cross-reaction with other stem-necrosis-causing *Pseudomonas* species. This polyclonal antibody can be produced

commercially and used for detection and identification of *P. viridiflava* from tomatoes and other potential hosts anywhere in the world.

Fatty acid (FA) analysis identified the tomato strains as *P. fluorescens* biotype I with similarity indices of 55 to 97%. The strains were divided into two main clusters on the basis of the FA analysis. This was the first report of *P. fluorescens* biotype I causing the disease in Turkey (Saygili *et al*. 2004).

One hundred and thirty strains of non-pathogenic rhizobacteria isolated from rhizoplane of healthy tomato plants were examined in a greenhouse pot test for their ability to reduce bacterial speck disease severity. While many of these strains significantly reduced disease severity, nine of the rhizobacteria strains were the most effective against *P. s.* pv. *tomato* by giving 52 to 63% reduction in disease severity as compared with the pathogen-alone treatment. Twenty combinations of these promising rhizobacteria strains were similarly tested in *in vivo* for induced resistance activity. Results indicated that three mixtures of rhizobacteria treatment reduced the severity of disease by 64 to 77%, compared to nonbacterized control (Aslan and Ozaktan 2004).

Treatment of tomato seedlings with DL-β-Amino butyric acid (BABA), at 500 µg ml^{-1} concentration, was resulted in 57% reduction in bacterial speck disease symptoms, caused by *P. s.* pv. *tomato*, compare with untreated control plants (Baysal *et al*. 2004).

In order to eliminate the inoculums of *P. c.* subsp. *caratovorum* and *P. chrysanthemi* from seeds; effectiveness of water at various temperatures, NaOCl, HCl, copper acetate, 8-hydroxyquinoline, bronopol and streptomycine applications and, effects of these applications on seed germination were determined. From the point of effectiveness of the applications and germinations ratios against *P. c.* subsp. *caratovorum* dipping of the tomato seeds for 3 min in NaOCl at 1% ratio and also against *P. chrysanthemi* dipping of the tomato seeds for 30 min in 0.6M HCI and 3 min in NaOCl at 1% ratio were proposed (Yildiz *et al*. 2005).

To evaluate the possibilities for controlling of tomato pith disease by using copper compounds and plant activators that induce systemic acquired resistance, the experiments were conducted in plastic greenhouse in 2001 and 2002 on seedlings of cultivar Fantastic 144 were artificially inoculated with *P. cichorii*. Tested copper compounds, including copper hydroxide, copper salts combined with mancozeb, copper salts of oil and rosin acids, and copper penta hydroxide, were sprayed on the pruning sites 3-4 hours prior to inoculation. Plant activators, including harpin, plant and yeast extracts (ISR 2000), and acibenzolar-S-methyl, were applied two times, five days prior to inoculation and on the day of inoculation. In both years, copper hydroxide was effective in disease reduction (72% in 2001 and 66% in 2002). Plant activators resulted in disease reductions ranging from 58% for acibenzolar-S-methyl to 20% for harpin (Ustun *et al*. 2005).

The effectiveness of three plant activators (Crop Set, ISR 2000 and Turf Set) against *C. m.* subsp. *michiganensis* was investigated. The results showed that height of plants increased between 6.96-18.26% ratios and disease occurrence were prevented between 27-73% ratios by these chemicals (Yildiz and Aysan 2005).

In the winter and early spring of 2002, a serious outbreak of stem rot and pith necrosis diseases with unusual fruit symptoms have been observed for the first time in greenhouses of the eastern Mediterranean region. Two different kinds of disease symptoms were determined, one of which (type 1) was characterized by wilting of the whole plant, water-soaking areas on the stem, hollowing of the pith, browning of the vascular tissue and maceration in stem and whole fruits. Type 2 was characterized by brown-black spots limited on the pruning sites of the stem and maceration in fruits, but not in stem. Fruit symptoms were initially round, black spots, followed by soft rotting around the spots but not the whole fruit). This is the first report of new symptoms of soft rot on tomato fruits caused by *P. viridiflava*, *P. c.* subsp. *carotovorum* and *P. chrysanthemi* in Turkey (Saygili *et al*. 2005).

PCR was used for identification of differences between *C. m.* subsp. *michiganensis* and the other seedborne bacterial organisms. In this study, 56 different bacteria cultures isolated from 70 tomato seed samples and nine isolates were detected as *C. m.* subsp. *michiganensis* (Geylani and Saygili 2005).

With the aim of detection of *C. m.* subsp. *michiganensis* by spectrofluometry following PCR incorporating a molecular beacon probe in the reaction, a DNA fragment (143 bp) from the virulence region (pat-1) of pCM2 plasmid of *C. m.* subsp. *michiganensis* was amplified in presence of the probe complementary to an internal segment of the amplified DNA fragment specifically designed oligonucleotide primers. Fuorescein and DABCYL were used as the fluorophore and quencher in the probe. A total of 24 virulent and avirulent strains of *C. m.* subsp. *michiganensis* from various geographic areas in Turkey were examined. Obtaining to results, the specificity of the fluorescence PCR assay was specific at 100% ratio compare to classical PCR. The sensitivity of detection by fluorescence measurement was found to be 10 bacteria ml^{-1}. The feasibility of the method was further approved by successful detection of *C. m.* subsp. *michiganensis* in naturally infected tomato seeds (Benlioglu and Ozyılmaz 2007).

Copper resistance of 25 *P. s.* pv. *tomato* strains isolated from Western Mediterranean Region were tested on the three different culture media (CYE, MGY and NA) containing 25 different doses ranging from 0-225µg ml^{-1} of copper sulphate and copper oxychloride. The interaction between plasmid profiles and copper resistance of the *P. s.* pv. *tomato* strains were determined (Deniz and Basim 2007).

A sensitive and selective TaqMan real time PCR method was developed for identification and detection of *P. s.* pv. *tomato*, *C. m.* subsp. *michiganensis* and *X. a.* pv. *vesicatoria*. The sensivity of designed primer and probe sets suitable for real time PCR was tested for different *C. m.* subsp. *michiganensis* and *X. a.* pv. *vesicatoria* strains plant pathogenic bacteria from different genus and species and tomato and pepper genomic DNA (Basim and Basim 2007a; Caplik and Basim 2009).

C. m. subsp. *michiganensis* strains isolated from tomato plants in different geographic locations were analyzed by Pulsed Field Gel Electrophoresis (PFGE) using rare-cutting restriction enzymes. The results of genome analysis of 30 domestic *C. m.* subsp. *michiganensis* strains were compared to those 9 different foreign countries strains, and the genome similarity and differences strains were showed. PFGE technique was developed in this study and used first time for the genome analysis of seed borne *C. m.* subsp. *michiganensis* strains (Basim and Basim 2007b).

A collection of 50 bacterial strains, antagonistic of *C. m.* subsp. *michiganensis* were isolated from rhizoplane of healthy plants of tomato, beans and cucurbits and olive trees as epiphytes and endophytes originating from different provinces of Aegean Region. Four strains reduced infection between the rates of 54 to 86% when applied as a seed treatment compared to the non treated control. These strains reduced the disease incidence by the rate of 80 to 97% when applied as a seed treatment followed by a root treatment before transplanting (Akat and Ozaktan 2007).

Soil disinfestation prior to planting in the case of greenhouse tomato production has become an important issue in Turkey because of the continuous plantation of the same crops. In greenhouse tomato production solarization alone and/or in combination with low dosage fumigant applications are being widely used in the Mediterranean region, which accounts for 90% of greenhouse tomato production in Turkey (Yucel *et al*. 2008).

Seed treatments such as hot water, hydrochloric acid, calcium hypoclorite, sodium hypoclorite and peroxyacetic acid were used for eliminating bacterial pathogens (Tokgonul 1998; Aysan *et al*. 2002; Yildiz 2002). One of the important bacterial diseases of the tomato grown in the greenhouses in Mediterranean Region is stem and pith necrosis

caused by *P. viridiflava* which is located on the surface of the tomato seeds (Yildiz *et al*. 2004). Ulke (2003) declared that 8-hydroxyquinoline and hot water (55°C) for 30 min caused 20% loss in germination of the seeds however bronopol was proposed because of no side effect and being practical. Bronopol and cooper acetate treatments were recommended in eliminating *P. s.* pv *tomato* from tomato seeds by Aysan *et al*. (2002). HCl (0.6M) for 30 min and NaOCl (1%) for 3 min. were reported as successful eliminating *P. chrysanthemi* from tomato seeds (Yildiz 2002). The effectiveness of sodium hypocloride (1%), HCl (0.6 M), 8 hydroxyqunoline (0.5-1%), cooper acetate (0.2%), streptomycine (at 50 and 100 ppm) and bronopol besides hot water treatment (at 50 and 55ºC) were tested on eradication of *P. viridiflava*. *P. viridiflava* from tomato seeds completely after hot water treatments at 50-55°C for 20 and 30 min, sodium hypoclorid (1%) treatments for 3, 4 and 5 min, HCl (0.6 M) treatments for 30 and 60 min, 8 hydroxyquinoline (0.5-1%) treatments for 3 min, cooper acetate (0.2%) treatments for 3 min, streptomycine (50 and 100 ppm) treatments for 5, 10, 15 and 30 min. The pathogen was also eliminated from seeds at 96% ratio after Bronopole (Bronotak, Agrevo) treatment. Treated seeds had an average germination rates ranging between 96 and 72% (Yildiz *et al*. 2009).

Totally 62 tomato, 14 water and 10 weeds bacterial strains were identified on the basis of biochemical tests, immunofluorescence (IF) and Real-time PCR as *Ralstonia solanacearum* biovar 2. This is the first report for the presence of the pathogen in the canal water and in some weeds in Turkey (Ustun *et al*. 2009b).

Two greenhouse experiments were carried out between the years of 2004-2006 in Aegean Region of Turkey to determine the influence of different potassium and calcium levels on severity of tomato pith necrosis caused by several pathogens belonging to genus *Pseudomonas* and *Pectobacterium.* The influence of three potassium (100 ppm, 200 ppm and 400 ppm) and two calcium (60 ppm and 120 ppm) levels on four different bacteria (*P. corrugata*, *P. cichorii*, *P. viridiflava* and *P. c.* subsp. *carotovorum*) were determined. Two years results showed that treatments comprising highest levels of potassium (400 ppm) and calcium (120 ppm) not only reduced disease index significantly for most of the bacteria, but also led to the highest yield (Ustun *et al*. 2009c).

Different *Rhizobacteria* strains, which were isolated from healthy tomato plants and effectively inhibited bacterial speck disease on tomato plants, were tested. Rhizobacteria inoculation were made seed coating and watering of plants after transplanting. The results indicated that rhizobacteria strains were effective against *P. s.* pv *tomato* by showing 27% to 77% reduction in disease severity (Ozaktan *et al*. 2009).

The roles of zinc (Zn) nutrition on the effectiveness of plant growth promoting rhizobacteria (PGPR) were investigated on the development of bacterial wilt disease in tomato plants. Effectiveness of PGPR by Zn fertilization increased as ratios of 43 and 37% in climatized room and greenhouse experiments, respectively. PGPR application with Zn fertilization increased dry matter weight by 29 and 36% in climatized room and greenhouse experiment, respectively. In this study, PGPR application with positive effect of Zn nutrition suppressed the bacterial disease of tomato and increased dry matter weight of the plants (Cakmak and Aysan 2009).

A total of 48 different Actinomycetes strains were isolated from 16 different hypersaline soil samples in Turkey and tested for their production of antibacterial compounds against 2 of *P. s.* pv *tomato* strains and *X. a.* pv *vesicatoria* strain. Only 17 strains of Actinomycetes isolated from 8 soil samples showed antimicrobial activity against tomato pathogenic bacteria. It was shown that halophilic Actinomycetes strains isolated from Turkey have the potential of inhibiting growth of tomato bacterial disease agents *P. s.* pv *tomato* and *X.a.* pv *vesicatoria* "*in vitro*" studies (Keser *et al*. 2009).

The effectiveness of plant growth regulator (Prohexadione-Ca (PC)), plant activator (hydrogen peroxide (HP)) and copper compounds (copper sulfate pentahydrate (CSP) and copper hydroxide) were determined on plant growth and disease incidence of *C. m.* subsp. *michiganensis* on three tomato cultivars 'Newton', 'Orient' and 'Vuslat'. The best chemical was found as HP on preventing of bacterial growth (39.26-48.61%). Only PC treatments have decreased plant heights (38-46%) and bacterial population (about 12%). CSP applications increased bacterial population between 4.15-7.69% in all of the cultivars. The results indicated that if integrated properly in plant health management programs, plant activators and growth regulators can be useful on plant health and growth (Bastas 2010a).

Inter simple sequence repeat (ISSR) markers showing high polymorphism ratios were selected and used to characterize *C. m.* subsp. *michiganensis* strains. The collected *C. m*. subsp. *michiganensis* strains were classified into different groups on the basis of ISSR-PCR fingerprints, which showed remarkable genetic specificity and diversity not previously identified in *C. m*. subsp. *michiganensis* suggesting that genetic differences are related to dissemination of the pathogen in the region. This was the first ever study carried out on the characterization of *C. m*. subsp. *michiganensis* using ISSR. The selected ISSR primers to characterize *C. m*. subsp. *michiganensis* can be used to determine genetic differences in further studies (Baysal *et al*. 2011).

P. s. pv. *tomato* strains were isolated from greenhouse tomato plants and seedlings from commercial vegetable seedling companies between 1997 and 2010 years in west Mediterranean region. Genomic differences of total 86 *P. s.* pv. *tomato* strains were determined by using rare-cutting restriction endonuclease enzymes including *Spe*I, *Xba*I, *Kpn*I, *Swa*I, *Nsi*I and *Ase*I were tested for genome analysis of the pathogenic bacteria. *Spe*I was determined to be useful an enzyme for determination of *P. s.* pv. *tomato* haplotypes. Six different haplotypes were determined from te total 86 strains by PFGE technique, and the genetic similarities of the haplotypes were compared with foreign strain of *P. s.* pv. *tomato* strains. Haplotypes obtained in this study will make an important contribution to tomato breeding efforts against to bacterial speck diseases, tracing and identification of the pathogenic bacterial strains (Basim and Basim 2011).

Thermal death point of *P. viridiflava* determined and effect of solarization treatment was tried aganist the bacteria in 1999 and 2000 years. As a result studies thermal death point of *P. viridiflava* was determined as 54°C. Solarization treatments caused 10.9-5.4°C and 7.9-3.6°C temperature increase in 0 and 15 cm soil depths, 5.0-2.6°C and 2.4-1.3°C in 30-40 cm soil depths respecively for two years. After solarization *P. viridiflava* was isolated from infected plant debris removed from 0 cm depth of control plot at 3.4×10^3 and 1.5×10^4 cfu/g densities, respectively for two years. On the other hand, the pathogen could not be isolated from solarised areas for two years. Based on all these data soil solarization was effective method in elimination of *P. viridiflava* from infected plant debris in soil (Yildiz and Cinar 2011).

Seven plant activators, organic and inorganic fertilizers (Auxigro, EM1, Herbagreen, ISR-200, Messenger, Protamin Cu, Regalia) against *C. m.* subsp. *michiganensis* were investigated on tomato. The preparations were applied to plants with three different applications (dipping to roots, spraying leaves and combinations of dipping to roots). Five preparations (ISR-2000, Messenger, Auxigro, Herbagreen and Regalia) in greenhouse pot studies and only ISR-2000 in open field study were found effective to disease. The best application was combinations of dipping to roots and spraying leaves. In the results of the study, plant activators, organic and inorganic fertilizers can be combined in integrated pest management of the disease (Soykan and Aysan 2011).

An antagonistic bacterium, Serenade, ISR 2000, sodium hypochloride, vinegar from grape, vinegar from apple, hot water and lactic acid were tested as seed treatments for

organic tomato production. It was detected that bacterial populations on seeds and contaminated seeds were decreased as 77-100 and 31-100% ratios by the seed treatments, respectively. Sodium hypochloride, vinegar from grape, vinegar from apple, hot water and lactic acid were found effective seed treatments. Seed germination was reduced 12.5% ration by hot water application. Reduced numbers infected seeds were also detected in lactic acid and sodium hypochloride treatments. Vinegar from grape and vinegar from apple recommended as the best seed treatments for organic tomato production based on effectiveness and seed germinations (Karut and Aysan 2011).

Kotan *et al*. (2010), the antibacterial effects of *n*-hexane, chloroform, acetone and methanol extracts and hydroidstilled essential oils and/or their major components of *Satureja spicigera* (C. Koch) Boiss., *Thymus fallax* Fisch and CA Mey, *Achillea biebersteinii* Afan, and *Achillea millefolium* L. evaluated on 25 phytopathogenic bacterial strains containing some vegetable bacterial pathogens, *C. m.* subsp. *michiganensis*, *P. s.* pv. *tomato*, *P. c.* subsp. *atrocepticum*, *E. chrysanthemi*, *P. cichorii*, *Xanthomonas axanopodis* pv. *vesicatoria*, *X. a.* pv. *campestris*, *X. a.* pv. *vitians*, *X. campestris* pv. *raphani*. The study was the first to report the antibacterial properties of the hexane extracts of *S. spicigera* and *T. fallax*. The results showed that essential oils of *S. spicigera* and *T. fallax* exhibited a broad spectrum of potent antibacterial activity against all tested bacterial strains. According to these results, carvacrol and thymol, and the essential oils containing high amount of these components have potent antibacterial effect against tested bacteria. In the same study, the essential oils of *S. spicigera*, thymol and carvacrol were determined as potential seed disinfectant agents against important seed-borne vegetable bacterial pathogens, *C. michiganensis* subsp. *michiganensis, P. syringae* pv. *tomato, X. axonopodis* pv. *vesicatoria* and *X. axonopodis* pv. *vitians.* Obtaining results showed that the essential oil of *S. spicigera*, carvacrol and thymol could be used as organic seed disinfection agents against the tested bacteria.

In addition, Dadasoglu *et al*. (2011), the chemical compositions of hydro-distilled essential oils and n-hexane extracts from *Origanum acutidens*, *O. rotundifolium* and *O. vulgare* analyzed by GC and GC-MS against 25 plant pathogenic bacterial strains. Essential oils showed a wide spectrum of antibacterial activity, probably due to the phenolic components such as carvacrol and thymol. It was also shown that carvacrol, thymol and other main components such as terpinen-4-ol and linalool possess antimicrobial activity. The findings suggested that the essential oils may be valuable as potential antibacterial agents against plant pathogens, and show the potential value of Origanum oils as seed disinfectant.

The resistance reactions of 44 popular tomato cultivars which are grown commonly in Turkey against *P. s.* pv. *tomato* causal agent of bacterial speck disease were determined by Ekici and Bastas (2012). The results of resistance reactions on plants were evaluated according to Chambers and Merriman scale. The total peroxidase activity (U/ml) was measured by a spectrophotometric method at λ=460 nm using H_2O_2 as a substrate in 24th, 36th and 72nd hours after bacterial inoculations. Presence of *pto* gene (963 bp) in the tomato cultivars was verified by using the spesific primers SSP17 and JCP32 by PCR and the gene was determined in 15 different tomato cultivars.

The role of reactive oxygen species in interactions between vegetables and pathogens was presented by Bastas (2012) in ASHS annual congress.

POTATO BACTERIAL DISEASES

Potato (*Solanum tuberosum* L.) is one of the most important field crops in Turkey, cultivated in 1593 ha with an annual yield of 4.397.305 tonnes (Anonymous 2006). In Turkey, commercially important potato cultivar is not bred yet; seed potato source is imported basic material. Out of 12,000 tons of approximate annual import of potato seed, 150.000 tons of commercial potato seed tuber of which 30% is certified, is produced (Kuşman 2008).

Bacterial diseases of potatoes in Central Anatolia were investigated by utilizing the EC method for the detection of ring-rot disease caused by *Clavibacter michiganensis* subsp. *sepedonicus* and using selective medium in 1988 and 1989. Ninety one samples containing 200 tubers from commercial and farmers' stores in Central Anatolia were tested for the presence of *C. m. sepedonicus* and about 50 tubers of each sample were also tested for the presence of soft-rot Pectobacterias. *C. m. sepedonicus* was not detected, but *P. c.* subsp. *carotovorum* and *P. c.* subsp. *atrosepticum* were present in 7 and 17% of the samples respectively (Benlioglu *et al*. 1991).

In vitro tests, the biological control activity of 151 fluorescent Pseudomonads against *P. c.* subsp. *carotovorum* were evaluated according to 0-5 scale. In the experiments with regardless variety of potato the highest inhibition rate was 52%. The results showed that inhibition of soft rot on tuber slices by fluorescent Pseudomonads varied depending on the variety of potato (Altın and Bora 2001).

Ralstonia solanacearum was detected for the first time on potato in 5 fields in Nevsehir province of Central Anatolia Region in 1995 and it was successfully eradicated. Second outbreak of the disease on potato was observed in May 2006 in Altınova town of Balıkesir province of Aegean Region. A study was carried out to determine the presence and prevalence of *R. solanacearum* in potato and tomato growing areas in Aegean Region. Totally 743 potato tubers and 62 tomato samples were analyzed and isolated bacteria were identified as *R. solanacearum* biovar 2 (race 3) on the basis of biochemical, immunofluorescence, real time PCR and pathogenicity tests. *R. solanacearum* was determined in 157 potato tubers (1876 d) and 62 tomato samples (671 d). Quarantine measures were taken in infested areas (Ustun *et al*. 2007).

One sample including 200 tubers for each 25 ton was taken after harvesting and 1386 samples were tested in Plant Protection Research Institute, Ankara. Twenty one samples gave similar results to positive control, however two samples were found as positive by real time Bio-PCR. According to all tests, two samples from Bolu province were found infected with *R. solanacearum* and production of potato and other hosts has been restricted to in these fields for 5 years (Karahan *et al*. 2007).

During the 2007 seed potato monitoring programme in Turkey, 336 tuber samples from Kayseri province were tested for the presence of ring rot and brown rot diseases. Three samples gave a positive immunofluorescence test (IF) result for *C. m.* subsp. *sepedonicus*. This was the first report of *C. m.* subsp. *sepedonicus* in Turkey. Strict control measures have been taken in contaminated and potentially contaminated fields since *C. m.* subsp. *sepedonicus* is a regulated quarantine organism in Turkey (Altundag *et al*. 2009).

CABBAGE, BROCCOLI, CAULIFLOWER and BRUSSELS SPROUTS BACTERIAL DISEASES

Brassicas are important and highly diversified group of crops grown world-wide (Monteiro and Lunn 1998). There are several grown and imported vegetables belonging to *Brassica* spp., particularly six *Brassica* species (kale, cauliflower, cabbage, brussel sprouts, kohlrabi and broccoli) (Nieuwhof 1969) and Turkey has 706.855 tons production from 30296 ha area in 2009 (FAO 2011).

In the winters of 2004 to 2006, severe leaf necrosis and vein rot symptoms were observed on cabbage (*Brassica oleracea* var. *capitata*), broccoli (*Brassica oleracea* var. *italica*), and Brussels sprouts (*Brassica oleracea* var. *gemmifera*) in the Mediterranean Region of Turkey. Infected seedlings were also observed in commercial nurseries in Adana with a disease incidence of nearly 10 to 25%. The isolates were identified as *Xanthomonas campestris* pv. *campestris* on the basis of biochemical tests, fatty acid

methyl ester (FAME) profiles and indirect ELISA. This was the first report of the occurrence and outbreak of *X. campestris* pv. *campestris* in the Mediterranean Region of Turkey (Mirik *et al*. 2008).

Sixteen different seed lot samples from Brassicaceous plants (13 cabbage (*Brassica oleracea var. capitata*), one cauliflower (*Brassica oleracea* var. *botrytis*), and two red cabbage (*Brassica oleracea* var. *rubra*) were assayed in terms of infestation rate and prevalence of plant pathogenic *Xanthomonas Pseodomonas* and *Erwinia* species and their identification. Totally 355 putative bacterial strains were obtained from seeds and diseased seedling developed from these seeds and identified by using traditional methods, host pathogenicity and serological (ELISA) methods. In examination of seedling tests, disease prevalence on seedlings develops from seeds under investigation varied between 5.8% and 51.6%. Two different plant pathogenic bacterial species belongs to *Erwinia* and *Pseudomonas* genus were detected in different seeds lots (Selcuk and Aysan 2011).

LETTUCE BACTERIAL DISEASES

Lettuce (*Lactuca sativa* L.) is an important field-grown vegetable and Turkey has 438.038 tons annual production (FAO 2011).

Xanthomonas axonopodis pv. *vitians* has previously been reported in Turkey (Sahin 2000). A severe disease indicating bacterial rot was observed on leaves of lettuce (*Lactuca sativa* cv. Tasna) grown in four commercial fields in the eastern Mediterranean region of Turkey. Disease incidence was estimated to approach 25–30%. This is the first report of the occurrence and outbreak of a bacterial rot disease caused by this bacterium on lettuce grown in Turkey (Aysan *et al*. 2003b). In winter 2002-2003, bacterial diseases caused by *X. a.* pv. *vitians*, *Pseudomonas cichorii* and *Burkholderia gladioli* were observed on lettuce plants in Cukurova Region. All strains were identified by biochemical tests and fatty acid analysis (Aysan *et al*. 2004b).

Kusek *et al*. (2005) researched percentages of seed contamination with *X. a.* pv. *vitians* on lettuce seeds, get from farmers, and effects of physical and chemical seed treatments on the seed contamination. To detect percentages of seed contamination with the pathogen, 200 lettuce seeds were sown in pods with sterile soil. After the research, percentage of seed contamination by the pathogen was 13.83%. The effects of three seed treatments, NaOCl (1%) for 3 min, HCl (0.6 M) for 30 min, and water hot (50ºC) for 20 min, were researched on the pathogen. There were no completely effective seed treatments. But, seed contamination ratio was reduced by hot water, NaCl and HCl by 39.4, 32.61 and 15.40%, respectively. The seed treatments have no effect on seed germination.

Varnish spot symptoms on lettuce were observed in late winter and spring of 2002 and 2008 in the Eastern Mediterranean region of Turkey. All of the bacterial strains isolated in the study were identified as *Pseudomonas cichorii* based on conventional methods, ELISA and fatty acid methyl ester analysis. The strains were divided into five different groups according to cluster analysis of fatty acid compositions in phenotypic characterization of the strains. This was the first detail study of *P. cichorii* causing stem and pith necrosis on tomato, bacterial rot and varnish spot on lettuce in Turkey (Mirik *et al*. 2011).

Acibenzolar-S-methyl (ASM, Bion 50 WG) was found to be more protective for lettuce against bacterial speck disease caused by *X. c.* pv. *vitians.* The findings show that ASM treatment in inoculated plants has long lasting effect to induce defense-related enzymes, contributing to the enhancement of plant resistance (Yigit 2011).

BEAN BACTERIAL DISEASE

Common bean (*Phaseolus vulgaris* L.) is an important legume grown worldwide for its high nutritional and economic value. In some countries, it is the primary source of protein in the human diet. According to 2008 data, the world leader in production of green bean is China, followed by Indonesia and then Turkey with 499,298 tones production (Anonymous 2011).

Halo and common blights are two bacterial diseases causing serious decrease in yield and quality of bean production in Turkey (Demir and Gundogdu 1994). A few bean cultivars in Turkey have been reported to be resistant and/or slightly resistant to the halo blight disease, but none of them was found to be resistant to common bean blight (Benlioglu *et al*. 1994).

Responses of different bean cultivars to nine races of *Pseudomonas savastanoi* pv. *phaseolicola*, the causal agent of halo blight of bean, were determined by applying pod and cotyledon inoculation technique. Among the cultivars, Roma II was found to be susceptible against all bacterial strains except race I. Sehirali-90, Yunus-90, Goynuk-98 and Karacasehir-90cultivars were found to be highly resistant against 3,3,5,3 different bacterial strains; Roma II, Sehirali-90, Karacasehir-90 were found to be moderately susceptible against 1,2,3 different bacterial strains, respectively. Among the bacterial races, race 6, 8 and 9 were found to be virulent on all bean cultivars tested. Race 3, 4 and 5 were found to be avirulent on all bean cultivars except Roma II (Bozkurt and Soylu 2001).

Turkish bean cultivars/lines tested for the first time and the bean line AG-7117 was determined as a new source of resistance against *Xanthomonas axonopodis* pv. *phaseoli* (Dursun *et al*. 2002).

During the 2006 growing season, a quantitative disease surveys were conducted to identify the fungal and bacterial causal agents associated with beanroot and foliar diseases in main common bean field in Hatay province.Two important bacterial diseases agents of bean *X. a.* pv. *phaseoli* and *P. s.* pv. *phaseolicola* were isolated from leaves and pods of bean plants with minor importance in the region (Vural *et al*. 2007).

Ninety one strains of nonpathogenic rhizobacteria from the rhizoplane and phylloplane of healty bean plants were examined for their ability to reduce bean common blight *X. a.* pv. *phaseoli* disease severity. All of the selected rhizobacteria strains reduced the disease severity by the range of 37 to 70% compared with the pathogen alone treatment. Six strains of the selected rhizobacteria were found more promising to control the pathogen than Acibenzolar-S-Methyl (55.65%) (Bozkurt and Ozaktan 2007).

Bean seeds were collected from economically bean growing areas which based size of sowing field on 12 provinces of Central Anatolia region. Morphological, biochemical, physiological and molecular methods were used for identification of pathogens on the seeds. In the region, infestation ratios of *P. s.* pv. *phaseolicola*, *P. syringae.* pv. *syringae*, *X. a.* pv. *phaseoli* and *Curtobacterium flaccumfaciens* subsp. *flaccumfaciens* were determined on the seeds as 21, 13, 11 and 0.8%, respectively (Bastas 2010b).

Some biological control agents were applied to *X. a.* pv. *phaseoli* infested bean seeds and/or seed-bed and prevention levels of the disease were examined. Bean cv. Akman 98 seeds were inoculated with bacterial suspensions (10^9 cfu ml^{-1}) of the pathogen. Seed applications were made as seed coating with *Penicillium* sp. + *Rhizobium* spp., dipping into suspensions in steril distilled water prepared of *Azotobacter* spp. + *Bacillus* sp. and copper sulfate compound, and spread of mycorrhizal fungi (*Glomus mosseae* and mycorrhiza coctail, 1000 spores kg^{-1}) onto seed bed. To determining the severity of the disease, 1-9 scale was used and according to the findings, the best plant growth and the lowest disease severity were obtained by *G. mossea* applications, and it was followed by *Penicillium* sp. + *Rhizobium* spp. and cocktail *Glomus* spp. applications, respectively. It is thought that these beneficial microorganisms can be used as an effective factor within a disease control program (Bastas *et al*. 2011).

The effectiveness of five PGPR and 15 plants extract on bean plants against *X. a.* pv. *phaseoli* and their effects on

plant growth were evaluated in glasshouse conditions. The disc diffusion method with a minor modification was used for testing of inhibitory activity. The minimum inhibitory concentration (MIC) values were determined by using modified disc diffusion method at five different concentrations and streptomycin sulphate was used as control chemical. Rhizobacteria strains isolated from rhizospehere and phyllosphere of some healthy plants were applied with a suspension of 10^8 cfu ml^{-1} after sowing at 3, 5 and 10 days and a virulent strain of *X. a.* pv. *phaseoli* (Xap12) was inoculated by inserting a hypodermic needle. Some growth parameters (plant height, fresh and dry matter weight) were determined 30 days later after applications. This study indicated that PGPRs and some plant extracts may be used in prevention programs to combat the common blight disease (Bastas *et al*. 2012).

P. s. pv. *phaseolicola, X. a.* pv. *phaseoli* and *X. a. pv. phaseoli* var. *fuscans* were identified and detected by Real-Time PCR method using LNA probe. Detection limits of the Real-Time PCR were found to be 7 cfu/ml and 3 cfu/ml from seeds, 2 cfu/ml and 3 cfu/ml from direct bacterial cell and 10 pg DNA from purifed genomic DNA, for *P. s.* pv. *phaseolicola* and *X. a.* pv. *phaseoli*, respectively (Ozturk and Basim 2011).

MUSHROOM BACTERIAL DISEASES

Mushroom cultivation has become very popular in many parts of Turkey and is a promising new industry, with many new businesses developing every year. Total fresh mushroom production of Turkey has increased 33-fold in the last 24 years, from about 1.400 tons in 1983 to about 46.200 tons in 2007 (Erkel 1992 and 2004; Gunay and Peksen 2004; Anonymous 2008).

Bacterial blotch, caused by *Pseudomonas tolaasii*, is the most common bacterial disease on *Agaricus bisporus* in Turkey (Bora *et al*. 1994; Ozaktan *et al*. 2000a; Basim 2004). Most biocontrol efforts against mushroom diseases have focused on bacterial blotch. The disease has been managed by *Pseudomonas fluorescens* biovars (Bora and Ozaktan 2000; Ozaktan *et al*. 2000b).

Ewingella americana causing human infections and internal stipe necrosis of cultivated mushrooms is the only species of the *Ewingella* genus in the family Enterobacteriaceae. Antibacterial activity of antibiotics and plant essential oils were tested against *E. americana*. *Satureja hortensis* essential oil among the tested plants showed the highest inhibition zone and the MIC value. This study indicated that some plant essential oils, carvacrol and thymol could be used as an organic pesticide for management of *E. americana* (Kotan *et al*. 2009).

PEA BACTERIAL DISEASES

Turkey currently produces approximately 93.000 t of peas annually and three-quarters of that is produced in Western Anatolia. Leaf blight symptoms were observed on field peas (*Pisum sativum*) grown in the Aegean Region of Turkey in 2009. Field inspections revealed disease incidence as high as 45%. Twelve strains (five from cv. 'Early Sweet', three from cv. 'Geneva', two from cv. 'Bolero', and two from cv. 'Carina') from 13 pea fields were obtained. On the basis of the physiological, biochemical, genetic, and pathological characteristics, all strains were identified as *Pseudomonas syringae* pv. *pisi*. This was the first report of *P. syringae* pv. *pisi* causing bacterial blight on pea in Turkey (Benlioglu *et al*. 2010).

PEPPER BACTERIAL DISEASES

Pepper is one of the most important vegetable species grown in our country. Turkey is in fourth rank in the world in view of vegetable production and at second rank by 1.84 million tons in terms of pepper production. Pepper production done by protected cultivation is 313,543 tones. The number of registered pepper variety in which commercial vegetable registration list has reached 178 units (Ozalp 2009).

Bacterial spot, caused by *Xanthomonas axonopodis* pv. *vesicatoria*, is one of the most important diseases of pepper in Turkey. The pathogen was isolated from tomato and pepper plants in greenhouse production in Antalya province of southwestern Turkey. Disease incidence was less than 4% of plants observed in 2001 and ranged from 1 to 20% in 2002 (Basım *et al*. 2004). Aysan and Sahin (2003) identified *X. a.* pv. *vesicatoria* as the major bacterial disease of peppers in the eastern Mediterranean region of Turkey. In Osmaniye province and its central districts, the pathogen was determined to have 52, 91 and 100% disease prevalence in 2002, 2003 and 2004, respectively (Mirik *et al*. 2005a).

During 2002-2004, plant samples with bacterial spot symptoms were collected from 83 commercial pepper fields in eastern Mediterranean region of Turkey. One hundred and seventy bacterial strains were identified as *X. a.* pv. *vesicatoria* by traditional methods and pathogenicity tests. Total 24 different fatty acids were detected in the whole cell of *X. a*. pv. *vesicatoria* strains tested were divided into two different groups in terms of fatty acids concentration and composition. There was no correlation between geographical origin and fatty acid groups of the strains (Mirik *et al*. 2005b).

The effects of different seed treatments including streptomycin, coper acetate, bronopol, hydroxyquinoline, HCl, NaOCl and hot water, on *X. a.* pv. *vesicatoria* were evaluated. The all seed treatments were significantly reduced the pathogen on contaminated pepper seeds. The best seed treatments were bronopol, hydroxyquinoline and HCl. The seed treatments were no effect on seed germination (Mirik *et al*. 2005c).

Effect of radish (*Raphanus raphanistrum*), mint (*Mentha piperita*), garlic (*Allium sativum*), oleander (*Nerium oleander*), eucalyptus (*Eucalyptus* sp.), pepper tree, terebinth tree (*Pistacia terebinthus*), onion (*Allium cepa*), pine (*Pinus sylvestris*), marata (*Clematis marata*) and rosmary (*Rosmarinus officinalis*) plant extracts on seed borne inoculums of *X. a.* pv. *vesicatoria* were investigated in *in vivo* and *in vitro* tests. *In vivo* tests, eucalyptus extracts were inhibited the disease completely (100%), garlic extract was inhibited the disease at 95% ratio. On disease effect of eucalyptus extract was 100% and effect of garlic extract was 24% (Mirik and Aysan 2002). Disease severity on tomato and pepper seedlings was reduced between 77 and 96% at ratios by garlic and eucalyptus extracts, respectively. In these studies demonstrated that aqueous garlic and eucalyptus extracts are effective seed treatments against seed borne infections of bacterial spot disease of tomato and pepper for traditional and organic seedling production (Mirik and Aysan 2005d).

The possibility of using PGPR, isolated from pepper fields in Adana and neighbor provinces, to biological control of *X. a.* pv. *vesicatoria* on pepper seeds was investigated. Each of the PGPRs and their dual and triple combinations as antagonistic bacteria were inoculated into the pepper seeds were infected with *X. a.* pv. *vesicatoria.* The results showed that the PGPRs and their combinations appeared to have reduced disease development by 24-83% (Mirik *et al*. 2005e).

The incidence and importance of natural infection in pepper seeds produced in the region was investigated in the present study. A total of 29 seed samples were tested by immunofluorescence assay using a commercial specific antibody, semi-selective isolation on medium Tween B. Pathogen populations were found to be in the range of 5×10^1-5×10^4 cells/g seed when using semi-selective medium Tween B. The diseased seeds as determined in the seedling screening ranged from 7 to 36%; these figures agreed with numbers found in the Tween B medium test (Mirik and Aysan 2009).

CARROT BACTERIAL DISEASES

According to the provincial agricultural directorate, 204.000 tons of carrots are grown in Kaşınhanı district of Konya province. Kaşınhanı produces 70 percent of Turkey's carrots and exports them to countries in the Balkans and the Middle East (Livaneli 2011).

Demir and Ustun (2001) tested totally 2469 plant propagative units for the presence of some plant pathogenic bacteria. They detected *Clavibacter michiganensis* subsp. *michiganensis* in 10 tomato seed samples, *Pseudomonas syringae* pv. *phaseolicola* in 3 bean seed samples, *Pseudomonas viridiflava* in 3 samples (cauliflower and cabbage seed) *Xanthomonas hortorum* pv. *carotae* in one carrot seed sample, *Acidovorax avenae* subsp. *citrulli* in one watermelon seed sample and *Ralstonia solanacearum* on 6 potato tuber samples were detected.

The Amik Plain, where over 35.000 ha areas are planted for carrot, is one of the main production areas for carrot in Turkey. In the result of bacterial isolations from diseased carrots roots, *Erwinia* spp. and strains belonging to fluorescent and non fluorescent plant pathogenic *Pseudomonas* spp. were obtained (Kurt *et al*. 2004).

MELON AAND WATERMELON BACTERIAL DISEASES

Vegetable production of Turkey is approximately 24 million tons covering approximately an area of 1 million ha. About 35% of the production comes from the species which belongs to the family *Cucurbitaceae*. Watermelon (*Citrullus lanatus*), melon (*Cucumis melo*), cucumber (*Cucumis sativus*), summer and snack squash (*Cucurbita pepo*), pumpkin (*Cucurbita maxima* and *Cucurbita moschata*) are the most commonly grown cucurbit in Turkey. The ratio of Cucurbit crops in total vegetable production is 32% (Sari *et al*. 2008).

In the winter of 2003 and 2004, severe leaf and stem necrosis symptoms were observed on watermelon (*Citrullus lanatus*) and melon (*Cucumis melo*) seedlings in two commercial nurseries at Adana, Turkey. The isolated strains were divided into two different groups according to cluster analysis of fatty acids. No correlation was found between watermelon and melon strains isolated. *P. viridiflava* has been reported previously on tomato in Turkey but this was the first outbreak on melon and watermelon in Turkey (Aysan *et al*. 2007).

Despite of being watermelon fruit blotch caused *Acidovorax avenae* subsp. *citrulli* in the host of all cucurbit plants (melon, watermelon, squash, cucumber), caused the highest damage on watermelon. Irregular light brown to reddish spots on leaves; small water-soaked areas on melon fruit surfaces and fruit cracks were observed in summer of 2010 in Çukurova Region. All the strains were pathogenic on melon (*Cucumis melo* cv. Surmeli) and watermelon (*Citrullis lanatus* cv. Blade) leaves. According to the results of the tests, strains were identified by *A. a.* subsp. *citrulli*. This was the first study on the presence of *A. a.* subsp. *citrulli* on melon in Çukurova Region (Horuz *et al*. 2011a). Karatas *et al*. (2011) found melon to be infected with *A. a.* subsp. *citrulli* Adana, Osmaniye and Mersin provinces the area about 4000 da. These areas were quarantined by the Ministry of Agriculture for four years by taking this prohibited the production of watermelon and melon fields. The disease was observed in the Crimson Tide, Zeugma, Crisby and Blade varieties in the study period.

To determine the effects of chlorine against *A. a.* subsp. *citrulli* on plant growth and suppressing of the disease severity, *in vitro* and *in vivo* experiments were carried on watermelon plants. In autoclaved chlorine, the most effective doses were in 0.35% and 0.40%, respectively. In filtered chlorine, the best effect was achieved in 0.20% and above doses. In both experiments, it was indicated that heat decreased the effect of chlorine. It was also determined that there is no negative effect on plant growth when watermelon seedlings were irrigated with 0.20% chlorine. The study was demonstrated that the pathogen population can be reduced by chlorine (0.20%doses) into the irrigation water (Horuz *et al*. 2011b).

CONCLUSIONS

Bacterial diseases cause significant economic losses to vegetables in some years in Turkey. This article mentioned about bacterial problems that are often encountered and includes bacterial diseases of tomato, potato, cabbage, broccoli, cauliflower, Brussels sprouts, lettuce bean, mushroom, pea, pepper, carrot, melon and watermelon for the last two decades. The most common bacterial diseases on vegetable crops were caused by five genera: *Pseudomonas*, *Pectobacterium*, *Clavibacter*, *Xanthomonas* and *Ralstonia*. In Turkey, the weather, especially cool and wet growing seasons, plays a critical role in determining both the incidence and severity of disease.

Disease management is a key concern in vegetable production. Modern facilities rely on strict sanitation and cultural controls to prevent bacterial outbreaks. Because few curative control methods are available, disease prevention practices are critical for both seed borne and foliar diseases. Foliar diseases create unique challenges; they are typically not predictable in timing and pressure, their source of origin can vary, and they are often best managed by using resistant varieties and seed treatments. The use of pathogen-free transplants is especially important for controlling bacterial diseases.

The primary goal of these researches has been to identify effective products and protocols that are environmentally safe, leave limited plant residue, and have a short worker reentry. Biological agents have been successful in controlling disease by inducing plant resistance, producing antibiotics, and out-competing pathogens. In general, the groups of materials that are acceptable for organic production include bicarbonate salts, essential oils, plant and soil extracts, and compounds that induce resistance to disease, and biological control organisms.

No single disease-control measure is adequate in limiting plant and yield losses in vegetable production. With a careful combination of disease-management approaches, including planting time, land selection and preparation, crop and variety selection, water management, and, when necessary, biological and chemical control, diseases in organic vegetable crops can be limited, and economic and environmental benefits can be achieved.

The bacteria that cause postharvest diseases of vegetables and fruits belong to five of the six genera of bacteria that cause plant diseases. Especially soft rot bacteria can cause important damages in storage conditions. There is no study conducted on this subject before in Turkey.

As a consequence, control programs for vegetable bacterial diseases must be adjusted every year to take the prevailing environmental conditions into account in order to achieve maximum control in Turkey.

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