REVIEW OF ANTIBACTERIAL ACTIVITY OF PLANT EXTRACTS AND GROWTH-PROMOTING MICROORGANISM (GPM) AGAINST PHYTOPATHOGENIC BACTERIAL TOMATO CROP

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ABSTRACT

Tomato is the second vegetable more important crop in the world, but has problems with bacterial phytopathogen that causes economic losses. The effectiveness of bioalternatives for controlling phytopathogen bacterial tomato disease is importance nowadays. Scientists are working on the development of new techniques for bioalternatives to control bacterial tomato diseases trying to avoid the traditional chemical control, because side effects can affect human health and causes damage at environment. In this review summarizes the alternatives compounds of some extract plants, as well as some compounds by *Bacillus* used as plant-growth promoting rhizobacteria, and some compounds by *Trichoderma* like an plant-growth promoting fungi.

Keywords: Agrobiotechnology**,** Plant-extracts, Beneficial-Microorganism, Bacterial-phytopathogenic, Tomato.

INTRODUCTION

The past few decades agricultural sciences intensified her studies on get more food production by agrochemicals compounds, those one present as a relatively method of protection and safe crops (Compant *et al., 2005*). However one of the major problems in agriculture today are due to pathogenic microorganisms that affect de health plant, by this way the quantity and quality of the crop products. Nevertheless, increasing use of chemical inputs causes several negative effects, development of pathogen resistance to the applied agents and their non-target environmental impacts (Sheikh *et al., 2013*). At the same time the increasing consumer demand for foods free or with low, if any added synthetic preservatives because could be toxic to human, forcing biotechnology agriculture to seek control sources against these microorganisms that are more friendly by environment and human(Agatemor, 2009). Several studies on the pathogen-toxic activities of plant secondary metabolites and beneficial microorganism have reported by bioalternatives control (Osorio *et al.,* 2010). These bioactive compounds are often active against a limited number of spices, including the specific targets, are biodegradable and potentially suitable for integrates use, they could be develop as a new classes of possibility safer diseases control agents (Soylu *et al.,* 2010).

Tomato (*Solanum lycopersicum*) is by far the most important vegetable crop; in terms of economic value, tomato constitutes 72% of the value of fresh vegetables produce worldwide (Hanssen *et al.,* 2010). With a worldwide production of 162 million metric tons and a value of over 37 billion international dollars in 2015 (Food and Agricultural Organization, United Nations, 2016). Number of biotic factors including viruses, bacteria, fungi and nematodes causing devastating diseases resulting in great economic losses (Arshad *et al.,* 2014) affects tomato production. Bacterial diseases are serious problem in the greenhouse and in open field production. The major pathogens are responsible for damage on tomato organs such as roots, stems, twigs, leaflets, leaf, buds, flowers and fruit in the war temperature regions of the world (Balestra *et al.,* 2009). These are *Pseudomonas syringae*, causal agent of bacterial speck; *Xanthomonas vesicatoria* causal agent of bacterial spot; *Clavivabter michiganensis* that causes bacterial canker, *Pseudomonas corrugate* agent causal of bacterial pith necrosis, *Ralstonia solanacearum* agent of bacterial built and *Agrobacterium tumefasensis* agent of crown gall disease (Yuliar *et al.,* 2015).

Actually have been report plant species with antifungal and antibacterial activities, mainly plant pathogens. For extraction of active phytochemicals against plant bacterial and fungal pathogens, the most commonly solvents used are methanol, ethanol, hexane, chloroform and diethyl ether (Mendez *et al.,* 2012). The use of the most of these solvents aren´t friendly by environment and aren't allowed in organic productions system, by this reason agrobiotechnology its focused on research on plants with high content polyphenols and organic solvents which are allowed to be used under organic production system (Castillo *et al*., 2010). The use of biologically based compounds in plant extracts its important because they constitute a rich source of phenols, flavonoids, quinons, tannin, alkaloids, saponins and sterols; some phytochemical of plant origin have been formulated as botanical pesticides and were considered successfully and friendly by environment and were integrated in pest management program (Soylu *et al.,* 2006).

In other hand agrobiotechnology, it has supported and focused in the development of use the beneficial microorganism on plant growth. Such as beneficial microorganisms referred as PGPR (plant-growth promoting rhizobacteria) or PGPF (plant growth promoting fungi) enhance plant growth trhoung numerous mechanism the protection of roots against infection by minor o major pathogens. (Gravel *et al.,* 2007). Rhizobacterias, defined as saprophytics bacterias that live in the plan rhizosphere and colonize the root system, as plant growth promoters. Colonization of the plant root system can lead reduced pathogen attack directly or competition for spaces, nutrients and ecological niches, and indirectly, through induction systemic resistance (Silva *et al*., 2003). The three families of *Bacillus* lipopeptides –surfactins, iturins and fengycins- were at first mostly studied for their antagonism activity for a wide range of potential phythopathoges. The different structural traits and physicochemical properties of these effective surface- and membrane-active amphiphilic biomolecules explain their involvement in the most of the mechanism developed by bacteria for the biocontrol of different plant pathogens (Ongena & Jaques, 2007). By other way, some fungus like *Trichoderma* have economic importance for production of antibiotics an enzymes, degradation of xenobiotic compounds, biological control and inductions of systematic acquired resistance in plants by endophytism (Zhou *et al*., 2007; Brunner *et al.,* 2005). *Trichoderma* species can improve plant growth promotion, evidenced by increases in biomass, productivity, stress resistance and increase nutrient absorption. Presumed mechanism involved in the stimulation of plant growth, included interactions with roots, where *Trichoderma* penetrates and colonizes root tissues without eliciting specific defense responses against the colonizing strain (Hoyos-Carvajal *et al.*, 2009). *Trichoderma* showed activity of glucanases, chithinases, cellulases and peroxidases evidence of the activation of the plan defense, also could produce metabolites with activities analogous to plant hormones (Harman, 2006).

The aim of this review consist on collect the currently results on investigation, by bio alternatives extracts and beneficial microorganism – *Bacillus* and *Trichoderma*- used by phytobacterial control on the tomato crop, to show the importance of using environmentally friendly technology.

Extracts Plants

Science ancient times, mankind has used plants to treat common diseases an some of these traditional medicines are still included as part of the habitual treatments of various maladies (Alviano & Alviano, 2009). The activity of plant extracts may therefore make possible in the actually the design of less expensive alternatives on different sciences as agrobiotechnology, to be used by friendly by environment, to generate a change on using chemical compounds (Castillo *et al*., 2010). Research on the use of plants is part of the ethnobotany, which has been define as the study of the interrelations between human groups and plants. For its interdisciplinary nature covers many areas including : botany, chemistry, medicine , pharmacology , toxicology , nutrition , agronomy , ecology , sociology , anthropology , linguistics, history and archeology , among others; allowing a wide range of approaches and applications (Bermúdez *et al.*, 2005). In Table 1, a compilation of the antibacterial shows properties of plant extracts used to control bacteria in different sciences areas in the world such as medicine, nutrition and agronomy. This in order to find alternatives that can be analyzed by agrobiotechnology to be efficient as antibacterial on tomato crop diseases and can be environmentally friendly with less secondary effects by health human. Research laboratories worldwide have found literally thousands of phytochemicals, which have in *in vitro* inhibitory effects on all types of microorganisms (Camacho-Corona *et al.*, 2015). Actually scientific data are accumulating that demonstrate for many herbs and related essential oils healing properties useful in the prevention of diseases or in relieve their symptoms. Therefore, plant extracts in the form of decoction, infusion, tincture or essential oils represent an important bioalternative by the population for treatment of several diseases on different sciences (Sheikh *et al., 2013*).

When infection or physical damages happen, many processes of the plant defense were activate. Some compounds were produce immediately, whereas phytoalexins are present only after two to three days (Alviano & Alviano, 2009). Phenolic compounds substances generally have significant antimicrobial activity as well as flavonoids. Some phytochemicals actually showed the presence of effective biological compounds like alkaloids, amino acids, flavonoids, phenols, tannins, terpenoids, saponins and cumarines (Ibrahim & Sarhan, 2015). These derivate could be potential alternatives to the traditional chemical control of clinical pathogen and phytopathogenic bacteria. Furthermore, the development of natural antibacterial will help to decrease the negative effects of chemicals controls (Riviera *et al.*, 2014). Fractionation and characterization of these active compounds will be the future bioalternatives by agricultural sciences. However, of the future commercial exploitation of the plants found to show significant activities must take in to account not only biological properties, including acceptable levels of toxicity, but also the growing habits, ease of cultivation and availability of these plants to the local population(Körpe *et al.*, 2012).

Table 1. Plants in world that showed antibacterial activity

Plant	Part used	Extract	Bioactive Compounds	Antibacterial activity	Reference
Allium stivum L.	Leaves	Hot and cold, water	ND.	*Ralstonia solanacearum*	Abo-Elyousr & Arnsan, 2006
Datura stramonium L.					
Nerium oleander L.					
Agave lechugilla	Leaves	Water, ethanol, lanolin and cocoa butter	Tannins, saponins and terpenes	*Enterobacter aerogenes, Escherichia coli, Salmonella typhi and Staphylococcus aureus*	Mendez *et al.*, 2012
Larrea Tridentata, tar bush F. *cernua*					
Lippia graveolen					
Yucca filifera					
Carya illinoensis	Husks on pecan nut				
Allium stivum L.	Clove	Water	Polyphenols, Allicin	*Pseudomonas syringae* pv. *tomato, Xanthomonas vesicatoria* and *Clavibacter michiganensis* subsp. *Michiganensis*	Belastra *et al.*, 2009
Ficus carica	Fruit				
Acccia nilotica	Leaves	Water	Alkaloids and Terpenoids	*Pseudomonas syringae and Xanthomonas axonnopodis*	Sheikh *et al.*, 2013
Catharanthus roseus					
Coleus aromaticus					
Plumbago zeylanica					
Santalum album					
Tinospora cardofolia					
Withania somnifera					

Propolis Turkey	ND	Methanol	ND	*Agrobacterium tumefaciens, Agrobacterium vitis, Clavibacter michiganensis* subsp.*michiganensis, Erwinia amylovora, Erwinia carotovora* pv. *Carotovora, Pseudomonas corrugata, Pseudomonas syringae* pv. *phaseolicola, syringae and tomato, Ralstonia solanacearum, Xhanthomonas campestris* pv. *campestris,and Xhantomonas axonopodis* pv. *vesicatoria*	Basim *et al.*, 2006
Pollen Turkey	ND				
Urtica dioica L.	Leaves, roots and seeds	Water and Methanol	Polyphenols	*Escherichia coli, Enterococcus gallinarum and fecalis, Streptococcus pyogenes, Staphylococcus aureus, Pseudomonas aureginosa, Shigella spp, Bacillus subtilis, Clavibacter michiganensis* subsp. *Michiganensis, Pseudomona syryngae* pv. tomato, *Xhantomonas axonopodis* pv. *vesicatoria, Erwinia carotovora and amylovora*	Körpe *et al.*, 2012
Urticua pilulifera L.					
Azadirachta indica A. *Juss*	ND	Essential oil	ND	*Clavibacter michiganensis subsp. michiganensis*	Borboa-Flores *et al.*, 2010
Brassica nigra					
Buxus chinensis					
Capsicum annuum					
Chaix mentha piperita					

L.					
Cinnamomun zeylanicum					
Citrus aurotinon L.					
Eucalyptus globulus Labill					
Lavandula officinalis					
Lippia palmeri Watson					
Medaleluca viridiflora Gaerin					
Melaluca alternifolia					
Origanum Vulgare L.					
Petroselinum sativum					
Ricinus comunis					
Rosmarinus officinalisL.					
Salvia Officinalis L.					
Thymus vulgaris L.					
Trigonella foenum graecum L.					
Lavandula angustifolia *Mentha pulegium* *Origanum dictamnus* *Origanum majorana* *Origanum Vulgare* *Rosmarinus officinalis* *Salvia fruticosa*	Complete plant	Essential oil	Cromatography-mass spectometry (GC-MS), alpha-pinene, camphene, beta-myrcene, alpha terpinene, p-cymene, beta-phellandrene,	*Clavibacter michiganensis* subsp. *michiganensis, Erwinia amylovora* and *Xhantomonas campestris*	Daferera *et al.*, 2003

Thymus capitatus			eucalyptol, terpinene, terpinolene, linalool, thujone, camphor, nerol, thymol, carvacol, neryl acetate		
Lippia origanoides	leaves	Petroleum ether, hexane and ethanol	Flavanoids, Tannins, steroids, alkaloids, carotenoids	*Escherichia coli, Pseudomonas aeruginosa, Aeroma hydrophilia, Proteus mirabilis, Enterobacter clocae, Klebsiella Pneumoniae, Staphylococcus aureus and Enteroccoccus galliarum*	Henao *et al.*, 2009
Ocimum basilicum L.	Leaves	Ethanol	Alkaloids,Flavanoids, Saponins, Tannins, Terpenoids and Steroids	*Escherichia coli*	Ibrahim & Sarhan, 2015
Larrea tridentata, tar bush F. cernua	Leaves and stems	70 % Ethanol	Tannins	*Enterobacter aerogenes, Escherichia coli, Salmonella typhi and Staphylococcus aureus*	Riviera *et al.*, 2014
Opuntia ficus-indicata	Paddle cactus				
Calycopteris floribunda	Flowers	Petroleum ether, chloroform and methanol	Phenols and Flavonoids	*Staphylococcus aerus , Bacillus cereus, Pseudomonas aeruginosa and Escherichia coli*	Pavithra *et al.*, 2013
Humboldtia brunonis					
Kydia calycina					
Acacia farnesiana	Flowers and leaves	Methanol	Flavanoids and quinones	*Klebsiella pneumoniae, Staphylococcus aureus,*	Menchaca *et al.*, 2013

Euphorbia antisiphylitica	Leaves			*Escherichia coli, Enterobacter aerogenes, Enterobacter Clocae*	
Fouquieriaceae splendens					
Leucophyllum frutescens					
Tecoma stans					
Larrea Tridentata	Leaves	Methanol, hexane, dicloromethane, ethyl acetate, ethanol	Dihydroguaiaretic acid (NDGA), Kaempferol and quercitin	*Staphylococcus saprhophyticus and epidermidis, Enterococcus faecalis,Pseudomonas aeruginosa, Klebsiella pneumoniae and Escherichia coli*	Martins *et al.*, 2013
Ambrosia ambrosioides	Aerial parts, fruits and Flowers	Methanol, clhoroform, dichloromethane and ethyl acetate	ND	*Mycobacterium tuberculosis*	Robles-Zepeda *et al.*, 2013
Ambrosia confertiflora					
Guaiacum coulteri					
Backousia citriodora	Plant Mixture	Water, ethanol and peptide	Phenols	*Staphylococcus aureus, Escherichia Coli, Bacillus cereus and Pseudomonas aeruginosa*	Shami *et al.*, 2013
Citru australasica					
Lophopyrim ponticum					
Terminalia ferdinandiana					
Aristolochia cymbifera	Stem	Water and ethanol	ND	*Prevotella intermedia, Phorphyromonas gingivalis, Fusobacterium nucleatum, Streptoccoccus mutans*	Aliviano *et al.*, 2008
Caesalpinia pyramidalis	Leaves				
Cocos nucifera	Husk fiber				
Ziziphus joazeir	Innerbark				

Artemisia nilagarica	Leaves	Chloroform, diethyl ether, ethanol, hexane, methanol and petrolumm ether	Alkaloids, Flavonoids, Phenols, Tannins, Quinines, Saponins and terpenoids	*Erwinia sp. Xhanthomonas campestris, Pseudomonas syringae, Clavibacter michiganensis, Yersenia enterolitica, Klebsiella pneumoniae, Salmonella typhi, Enterobacter aerogenes, Proteus vulgaris, Pseudomonas aeruginosa, Shigella falxneri, Bacillus subtillis, Enterococcus faecalis, Staphyloccoccus aureus.*	Ahameethunisa & Hopper, 2010
Alhagi maurorum *Chenopodium murale* *Convolvulus fatmensis* *Conyza dioscoridis* *Cynanchum acutum* *Diplotaxis acris* *Euphorbia cunaeata* *Origanum syriacum* *Solenostemma argel* *Tamarix aphylla*	Leaves	Ethanol	ND	*Escherichia coli, Moraxella Lacunata, Proteus merabiles and vulgaris, Pseudomonas aeruginosa, Salmonella typhi, Bacillus subtillis, Mircococcus Kirstiniae, Micrococcus luteus, Sarcina ventricull, Staphylococcus aureus, haemolitucs and byogenes*	Zain *et al.*, 2012
Allium stivum L. *Datura stramonium L.* *Sara indica*	Complete plant	Ethanol	Saponin, tannin, scopolamine, atropine, allicin, flavonoids, chrysin, liquiritigenin, naringenin, kaempferol and quercitin	*Vibrio spp.*	Sharma & Patel, 2009

Lonicera alpigena *Castanea sativa* *Juglans regia* *Ballota nigra* *Rosmarinusofficinalis* *Leopoldia comosa* *Malva sylvestris* *Cyclamen hederifolium* *Rosa canica* *Rubus ulminifolius*	Complete plant	Ethanol	ND	*Staphylococcus aureus*	Quave *et al.*, 2008
Crataegus mexicana *Hyptis albida* *Ocimum baislicum* *Prunucs serotina*	Leaves and Fruits	Water, hexane, ethanol	ND	*Stenotrophomonas maltophilia, Escherichia coli, Acinetobacter baumannii, Pseudomonas aeruginosa, Klesiella Pneumoniae, Streptoccocus aureus, Listeria monocytogenes, Enterocccus faecalis and Mycobacterium tuberculosis*	Camacho-Corona *et al.*, 2015
Melia azederach L.	Leaves	Ethanol	ND	*Escherichia coli, Pseudomonas aeruginosa, Klebsiella oxytoca, Enterobcoccus faecalis and Burkhordelia glumae*	Sierra *et al.*, 2012

*Not determinate (ND) by reference author.

Bacillus as Plant-growth promoting bacteria (PGPB)

The population dynamic of the human has led to the exploitation of natural resources in search of a way to meet the nutritional needs of the billions of people inhibiting the planet. This need has led to the uses of high-efficiency chemical materials in agriculture; strategies used in modern agriculture have negative environmental impact that human yet fully understand (Castillo *et al.,* 2010). As an alternative to the use of chemical compounds, the use of rhizopheric bacteria has been proposed as plant growth promoting bacteria (PGPB); these bacteria can stimulate de growth directly or indirectly and show several mechanism that interact with each other to establish beneficial relationships, especially with the roots of target plants (Camelo *et al.,* 2011). Between direct mechanisms, it´s found the biological nitrogen fixation (BNF), production of hormones plants (PHP), and biosolubilization by phosphate (BP). In other way indirect mechanisms covers biocontrol mechanism by antagonism (BMA), which can be by presence of antibiotics, siderophore, auxins, lytic enzymes and antifungal metabolites, others indirect mechanism can be by controllers stress, by regulation of ethylene levels in plant (CS), induced systemic resistance (ISR) or volatile organic compounds (VOCs) (Molina-Romero *et al.,* 2015). Representatives of many different bacterial genera have been introduce into planting materials to improve growth crop. These bacterial genera *Acinetobacter, Agrobacterium, Arthrobacter, Azopirillum, Bacillus, Bradyrhizobium, Frankia, Pseudomonas, Rhizobium, Serratia, Streptomyces and Thiobacillus,* and many other has been reported with rhizobacteria growth promoting activity in tomato crops (Alfonso *et al.,* 2005; Haas & Défago, 2005, Kloepper *et al.,* 2004; Nihorimbere *et al.,* 2010).

A number of *Bacillus* strains express activities that suppress necrotizing pathogens/parasites or otherwise promote plant growth (Choudhary & Johri, 2009). The most studied of the insect pathogens are those classified as *Bacillus thuringiensis* which is distinguish from the common saprophytic species. Several species of *Bacillus* produce toxins that are inhibitory growth or activities fungal, bacterial and nematode pathogens of plants, wherein most thoroughly studied species include *B. subtilis* (Pinchuk *et al.*, 2002). In addition, a number of studies reported direct antagonism by several species that include *B. amyloliquefaciens, B. cereus, B. licheniformis, B. megaterium,* and *B, mycoides* and *B. pumilis* (Choudhary and Johri, 2009). In Table 2, examples of these and others bacteria's are show with their action against phytopathogen of some plants. *B. subtilis* strains have been develop commercially as a formulation and testes against several crop diseases (Latha *et al.,*2009), cells by these are capable of forming dormant spores that are resistance to extreme conditions and thus can be easily formulated and store (Chen *et al.,* 2013). *B. subtilis* produce, catabolic enzymes like proteases, chitinases and glucanases, produces peptide antibiotics and small molecules to contribute to pathogen suppression. Some lipopeptide antibiotics of *B. subtilis* can be iturin A and surfactin that could suppress diseases on tomato whereas zwittermicin A from *B. cereous* hove correlated to suppression disease in alfalfa (Ramamoorthy *et al.,* 2001 & Kloepper *et al.,* 2004).

The action mode of PGPB is not always the same, depends on the plant and crop with which they are interacting. PGPR is a multigene process influenced by some factors, therefore understanding of these processes and elucidate the mechanism of control tomato phytopathogenic bacteria need continue developing knowledge by scientific and agrobiotechnology sciences (Srivastava *et al*., 2012).

Table 2. Bacterial biocontrol in different plants by beneficial bacteria's.

Bacterial Strain	Plant species	Pathogen	Mechanisms, activity or elicitors	References
P. aeruginosa 7NSK2	Tomato	*Botrytis cinerea*	Pyochelin and Pyocyanin	Audenaert *et al., 2002*
P. fluorescens CHAO	Tomato	*Meloidogune javanica*	2,4 DAPG (siacetypholoroglucinol)	Siddiqui & Sakuat, 2004
P. fluorescens Q2-87	Arabidopsis	*Pseudomonas syringae* pv. *Tomato*	2,4 DAPG (siacetypholoroglucinol)	Weller *et al.*, 2004
P. fluorescens GRP3	Tomato	*Pseudomonas syringae*	Siderophores	Meziane *et al., 2005*
Bacillus sp. BB11	Tomato	*Ralstonia calanacearum*	Biological control	Jian-Hua *et al.*, 2004
P. aureofaciens, corrugata and aphanidermatun	Cucumber	*Pythium aphanidermatum*	Stimulated activity enzymatic of phenylalanine ammonia-lyase (PAL), perxidase (PO), and polyphenol oxidase (PPO)	Chen *et al.*,2000
B. subtilis CBR05	Tomato	*Xanthomonas campestris* pv. *Vesicatoria*	Stimulated activity enzymatic of superoxide dismutase (SOD), catalase (CAT), peroxidase (POD), and polyphenol oxidase.	Chandrasekaran & Chun, 2016
B. hunamae MTI-641	Tomato	*Burkholderia unamaer*	Biological nitrogen fixing and enzymatic activity by 1-aminoacilclopropan-1-coboxylate desaminase	Caballero-Mellado *et al.*, 2004
B. amyloliquefaciens S13-3	Tomato	*Ralstonia solanacearum and Oidium neolycopersici*	Antibiotic production	Yamamoto *et al.*, 2015
A. zospirillum brasilense	Tomato	*Clavibacter michiganensis subsp. Michiganensis*	Antibiotic production	Romero *et al.*, 2014

B. Subtilis	Tomato	*Clavibacter michiganensis subsp. Michiganensis*	Bilogical control	Rojas, 2014
B. thuringiensis BUPM103	Tomato	*Agrobacterium tumefaciens*	Bacteriocin	Kamoun *et al.*, 2011
B. methylotrophicus 39b	Tomato	*Agrobacterium tumefaciens*	Lipopeptides as surfactins, iturins and fengycins	Frikha-Gargouri *et al.*, 2017
B. amyloliquefaciens SQR-9	Tomato	*Ralstonia solanacearum*	Volatile organic compounds (VOCs)	Raza *et al.*, 2016
Streptomyces spp.	Tomato	*Clavibacter michiganensis subsp. Michiganensis*	Biological control	Zhang *et al.*, 2010
R. aquatilis	Tomato	*Xanthomonas campestris pv. vesicatoria*	Biological control	El-Hendawy *et al.*, 2005
B. amyloliquefaciens and pumilus	Tomato	*Xanthomonas campestris pv. Vesicatoria*	Stimulated activity enzymatic of, perxidase (PO), and polyphenol oxidase (PPO)	Lanna-Filho *et al.*, 2013
B. subtilis QST 713	Tomato	*Pseudomonas syrigae pv. Tomato*	induced systemic resistance (ISR) genes PR1a, PR1b and Pin 2	Fousia *et al.*, 2016
B. subtilis, amyloliquefaciens, cereus, and pumilus	Tomato	*Fusarium solani*	Phosphate solubilization, Hydrogen cyanide (HCN) production, Indole acetic acid (IAA) production	Ajilogba *et al.*, 2013
B. megaterium MB3, subtilis MB14, subtilis MB99 and Amyloliquefaciens	Tomato	*Rhizoctonia solani*	Able to produce chitinase, B-1,3-Glucanase and protease	Manoj *et al.*, 2012

Trichoderma as plant growth promoting fungi (PGPF)

Another alternative to control phytopathogen bacteria's in tomato in the biological control as plant growth-promoting agent is *Trichoderma* spp. These agent is the most studied for their effects on reducing plant diseases (Avis *et al.*, 2008). *Trichoderma* (teleomorph Hypocrea) is a hemibiotitrophic fungus effective in reducing the severity of plant diseases trough several mechanisms, such as antagonism and mycoparasitism attacking or inhibiting the growth of plant pathogens directly or by inducing systemic and localize resistance plants (Fontanelle *et al.*, 2011). The fungal genus *Trichoderma* includes species of economic importance for production of antibiotics and enzymes, degradation of xenobiotic compounds, biological control activity against fungi, bacteria's and nematodes, and induction of systematic acquired resistance in plants by endophytism (Hoyos- Carvajal *et al.*, 2009). *Trichoderma* are widely used as biofertilizer and biopesticide in commercial formulates because of the multiple beneficial effects on plant growth a diseases resistance. (Tucci *et al.*, 2011). The genus *Trichoderma* produce numerous bioactive secondary metabolites which are species and strains dependent, including volatile and nonvolatile antifungal substances, some rhizophere-competent strains that can colonize root surfaces have been shown to have direct effects on plants, increasing their growth potential and nutrient uptake, fertilizer efficiency utilization, percentage and rate of seed germination (Gal-Hemed *et al.*, 2011.) However, it is also reported that all the isolates of *Trichoderma* spp. are not equally effective in control of pathogen *in- vitro* and *in-vivo* conditions to control diseases. Therefore, specific isolates are needed for successful control of particular pathogen, in Table 3 shows examples of *Trichodermas* as a biocontrol agent against different bacterial pathogens crops. The most common biological control agent of the *Trichoderma* genus strains are *Trichoderma harzianum, Trichoderma virens and Trichoderma viride* (Xiao-Yan *et al.*, 2006).

Table 3. Different *Trichoderma* strains against bacterial pathogens

***Trichoderma* Strain**	**Plant**	**Pathogen**	**Mechanisms, activity or elicitors**	**References**
T. harzianum	Tomato	*Clavibacter michiganensis subsp. michiganensis*	Lysosime and prevent activity	Utkhede & Koch, 2004
T. asperelloides T203	*Tomato*	*Pseudomonas syringae* pv. *tomate*	Increase level of WRKY 40 trascription factors and lipid transfer protein (LTP4)	Brotman *et al.*, 2012
T. atroviride and virens	*Tomato*	*Alternaria solani* and *Pseudomonas syringae* pv. *tomate*	Secret protein Sm1 and Epl1, wich elicital local and sistemic disease resistance.	Salas-Marina *et al.*, 2015
T. harzianum and asperellum	*Tomato*	*Xhantomonas campestris pv. vesicatoria*	Inducing acquired systemic disease resistance by chitinolytic and b-1,3-glucanolytic activitie	Saksirirat *et al., 2009*
T. harzianum	*Tomato*	*Xhantomonas campestris pv. vesicatoria*	Biocontrol activity, antagonism dosage	Suárez-Estrella *et al.*,2014
T. harzianum	*Tomato*	*Ralstonia Solanacearum*	Biocontrol activity	Liza & Bora *et al;* 2009
Trichoderma spp.	*Tomato*	*Xhantomonas euvesicatoria*, and *Alternaria solani*	Antagonistic activity, are able to degrade cellulose	Fontenelle *et al.*, 2011
T. harzianum T23	*Activity in-vitro*	*Clavibacter michiganensis and Erwinia Amylovora*	Production of viridiofungin A (VFA)	El-Hasan *et al.*, 2009
T. reesei	*Arabidopsis and tomato*	*Clavibacter michiganensis*	Production extracellular ezyme swollenin	Saloheimo *et al.*, 2002
Trichoderma spp.	*Rice*	*Xhantomonas oryzae* pv. *Oryzae*	Biocontrol activity	Gokil-Prasad & Sinha, 2012

T. harzianum	*Cotton*	*Xhantomonas campestris pv. Malvacearum*	Induction of Systemic resistance by activity of peroxidase, phenylalanine ammonialyase, polyphenol oxidase an b-1,3-glucanase	Raghavendra *et al.*, 2013
T. asperellum T-203	*Cucumber*	*Pseudomonas syringae pv. Lachrymans*	Induction of sytemic resistance and accumulation of phytoalexins	Yedida *et al.*, 2003
T.harzianum	Soil, vermicompost	*Ralstonia Solanacearum and Meloidoyne incognita*	Biocontrol activity	Liza & Bora *et al.*, 2009
T. harzianum and viride	*Potato*	*Erwinia carotovora subsp. Carotovora*	Antagonistic effect	Sandipan *et al.*,2015
T. virens PS1-7	*Rice*	*Burkholderia plantarii*	produced carot4-en-9,10-diol a sesquiterpene-type autoregulatory signal molecule	Wang *et al., 2013*
T.asperelloides	*Cucumber*	*Pseudomonas syringae*	Protein swollenin, local defense	Brotman *et al.*, 2008
T.virens	*Cucumber*	*Pseudomonas syringae*	Elicitation of systemic defences by 18 mer peptaibols	Viterbo *et al ., 2008*
T. harzianum and viride	*Banano*	*Ralstonia solanacearum race 2*	Biocontrol activity	Ceballos *et al., 2014*
T. asperellum T34	*Arabidopsis*	*Pseudomonas syringae* pv. *tomato*	MYB72, a node of convergence in induced sytemic resistance triggered	Segarra *et al.*, 2009
T. Koningii SMF2	*in vitro*	*Ralstonia solanacearum, Erwinia carotovora*pv. *Catotovora* and *Clavibacter michiganensis* ssp. *michiganensis*	Antimicrobial metabolits (Trichokonins)	Xia-Yan *et al.*, 2006

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CONCLUSION

The need for increasing agricultural productivity and quality has led to an excessive use of chemical fertilizer, creating serius environmental pollution. The use of biofertilizers an biopesticides is an alternative for sustaining high production with low ecological Impact. This review records several results about the use of extract plants, plan growth promoting rhizobacteria and fungi (with potential bioactive properties that exhibited significant antimicrobial, antioxidant activity and growth activity) that support their use in the treatment of some phytopathogen tomato diseases. The Table 1, 2, and 3 shows the summary of some bioalternatives that can be use by agricultural science. Attention to this issue could usher in badly needed new area of bioalternative control treatment on bacterial tomato crop diseases by using friendly alternatives with environment. Finally, additional tests, including development of experimental models evaluating the agricultural applicability, are required before considering these options real promising compounds.

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