Scientific Papers. Series B, Horticulture. Vol. LXII, 2018
Print ISSN 2285-5653, CD-ROM ISSN 2285-5661, Online ISSN 2286-1580, ISSN-L 2285-5653

EFFICACY OF PLANT BASED BIOPRODUCTS AGAINST TOMATO SEEDLINGS DAMPING-OFF DISEASE-SHORT OVERVIEW

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Abstract

Most European countries are investing in research to reduce reliance on pesticides and the risks associated with their use. At this moment, farmers' access to a wide range of pesticides is predicted to become limited due to legal regulations regarding sustainable use of pesticides. Therefore, the modern farmers will have to incorporate innovative pest and disease management approaches to reduce their dependency on pesticide use. This study presents an overview about the recent results on the efficacy of natural products obtained from plant extracts to control tomato seedlings damping off disease. It was already demonstrated that several plants contain secondary metabolites that are toxic to plant pathogenic microorganisms infecting horticultural crops, especially on the early emergence of the disease. The rich phenolic compound solutions possess antimicrobial effects and serve as plant defense mechanisms against plant pathogens. For using these products with reproducible efficiency, it is important to compare their mode of action for the optimization of the manufacturing process, the stabilization of these preparations, dates and rates of application.

Key words*: plant bioproducts, tomato disease, plant extract.*

INTRODUCTION

Plant diseases cause significant economical loses in horticultural production every cultivation season. Despite the continuous research on resistant cultivars, the crop losses are still being observed. More often, the intensive use of chemical pesticides resulted in inappropriate application of doses and has not only created fungicide resistance and increased soil contamination, but may also trigger imbalance in the microbial community (On et al., 2015) and a degradative effect on the ozone layer (Goudjal et al., 2014). Moreover, the access of farmers to a wide range of pesticides is predicted to become limited due to legal regulations regarding the implementation of integrated pest management and sustainable use of pesticides. As a result, most countries assign important resources to search for solutions to reduce reliance on pesticides and the risks associated with their use. The occurrence of serious plant diseases can occur at the early stage of seed germination and seedling emergence. Damping off disease and rot of crown and root of seedlings is caused by several different phytopathogens. This disease causes emerging seedlings to collapse and once infected, the seedlings rarely survive to produce a vigorous plant. The period of growth between planting and maturity, is considered as critical, and special attention should be paid to protect sensitive seedlings. As a potentially useful protection strategy, the use of plant products such as essential oils and plant extracts against several plant pathogens has already been demonstrated. Tomato (*Lycopersicon esculentum* Mill.) belongs to nightshade family *Solanaceae*. It is the second extensively grown vegetable crop after potato due to its tangy fruit, taste and high nutritive value containing vitamins particularly vitamin A, C, β-carotene and essential minerals (Chohan et al., 2017; Goudjal et al., 2014).

This study presents an overview about damping off tomato seedlings pathogens and the reported efficacy of natural products obtained from plant extracts to control this disease.

CAUSAL PATHOGENS FOR DAMPING-OFF OF TOMATO SEEDLINGS

Almost all species of vegetables (tomatoes, cucumber, eggplants, radishes, beans) can be

affected by damping off. The young leaves, roots and stems of newly emerged seedlings are highly susceptible to fungal or fungus like infections.

When meeting proper conditions, damping-off pathogens may also cause the rot of root or crown rot in mature plants. Cool and cloudy weather, excessive irrigation resulting in wet or compacted soil, poor ventilation and high humidity due to overcrowding are just few of the prerequisites for damping-off.

Damping off may occur before or after seed germination. In pre-emergence, the seeds will basically fail to germinate after sowing. They appear soft, dried or mushy, with necrotic radicle. In post-emergence damping-off, the seedlings will decay shortly after they have emerged from the soil wards Table 1 (Kato et al., 2013; Pagoch et al., 2015).

The causal agents of damping off are soil borne pathogens that are also able to survive quite well in plant debris, on contaminated tools, pots and potting media. Their spores can be carried by insects like fungus gnats, or can be transported in in irrigation pipes and drainage water. Some pathogens can be introduced on dirty hands, contaminated tools or by hose ends that have been in contact with dirt and debris.

Rhizoctonia spp. and *Fusarium* spp., along with the water mold *Pythium* spp. and *Phytophthora* spp. are the most common pathogens responsible for damping off of many vegetables seedlings, including tomato (*Lycopersicon esculentum*) (Chohan et al., 2017).

Table 1. Key features of fungi or fungal like organisms responsible for attacks on tomato seeds and seedlings (adapted from Blancard, 2012)

Pathogen	Symptoms	Attack frequency	Differentiating structures
***Pythium* spp.** (damping-off)	Soft wet brown rot on the stem base and roots.	Frequently	Oospores, sporangia, and chlamydospores
***Phytophthora* spp** *P. erythroseptica, P. citricola, P. capsici, P. cryptogea, P. nicotianae* (damping-off)	Brown rot on the stem and roots.	Frequently	Oospores, sporangia, and chlamydospores
Sclerotium rolfsii (damping-off, stem base rot)	Brown rot surrounding the stem and extending to the roots level.	Mainly in traditional nurseries in tropical areas.	White mycelium covering seedlings and soil. Spherical sclerotia (1-3 mm), white to brown.
Rhizoctonia solani (damping-off, stem base rot)	Reddish brown wounds on hypocotyl and epicotyl before emergence. After emergence, reddish brown to black spots, on the seedlings	Quite frequently	Compartmentalized mycelium, with a constriction at branches.

The control and prevention of these pathogens is mainly done by application of agrochemicals. However, the present movement towards environmentally safe methods in sustainable agriculture calls for reducing their use.

Recent research directions are focusing on developing environmentally friendly products for the management of plant diseases.

Natural plant products are considered a potential solution as they are important sources of new agrochemicals for the control of plant diseases (Nashwa et al., 2012). Furthermore, plant-based products are easily biodegradable.

PLANT PRODUCTS WITH ANTIFUNGAL ACTIVITY

In a study reported by Singh et al. (2012), four plant products obtained from leaf extracts were tested for their potential antifungal activity against *Pythium aphanidermatum*, the causal pathogen of damping-off of tomato seedling. All products showed significant inhibitory effect on the mycelial growth of the test pathogen, as compared to chemical fungicide control (Bavistin 0.2%). The leaf extract from *Eucalyptus globulus* (92.78%) showed maximum mycelial growth inhibition followed

by *Azadirchta indica* (72.91%) extract (Singh et al., 2012).

The antifungal activities of plant products are attributed to different chemical compounds like phenols, flavonoids, isoflavonoids, coumarins, pyrones, alkaloids etc. present in these plants which effect the growth of pathogenic fungi. For example, the main components of *Eucalyptus* sp. essential oil, determined by GC-MS are β-Cymene (32.1%), Eucalyptol (36.59%), Cryptone (4.35%) and Spathulenol (3.82%) (Rusu et al., 2014).

In a recent study, *Ocimum* species essential oils were evaluated for their *in vitro* antifungal effect through poison food technique against *Rhizoctonia solani* and *Choanephora cucurbitarum*. *Ocimum tenuiflorum, O. gratissimum,* and *O. kilimandscharicum* exhibited complete growth inhibition of both pathogens (24 and 48 h after treatment). Nevertheless, *O. basilicum* showed variable levels of fungal growth inhibition (63.0%-100%). Moreover, the composition of the tested essential oils was analyzed and compared by using capillary gas chromatography (GC/FID) and GC-mass spectrometry (GC/MS). Phenyl propanoids (upto 87.0%) and monoterpenoids (upto 83.3%) were prevalent constituents distributed in the studied O*cimum* taxa (Padalia et al., 2014).

An essential oil of *O. basilicum* and *Cymbopogon citratus* was also tested against three *Phytophthora* species under *in vitro* and greenhouse conditions compared to fungicides. However, *C. citratus* had the lowest EC_{50} values for in vitro inhibition of the mycelial growth of *Phytophthora* spp (between 31.5 and 69.1). In greenhouse, *C. citratus* essential oil reduced disease severity from 47.4% to 60.5% compared to the untreated control (Amini et al., 2016). More recently, another *Ocimum* specie (namely *Ocimum gratissimum*) essential oil was tested for antifungal activity against several isolates of *Fusarium* spp., *Rhizoctonia solani*, and *Macrophomina phaseolina*. The broth microdilution method revealed that *F. oxysporum* f. sp. *lycopersici* and *R. solani* were the most sensitive strains (Mohr et al., 2017).

Rhizoctonia solani is very common soil fungus and is widespread in the world. It can be considered as a biomarker of so called 'sick' soil (Blancard, 2012). In a more extensive research, fifty five species of medicinal plants were employed for *in vitro* antifungal activity testing against *Rhizoctonia solani* AG 2-1 and *Trichoderma harzianum.* The aim was to improve the biocontrol efficacy of *T. harzianum*. *Cinnamomum loureirii* stem bark extract inhibited mycelial growth of *R. solani* AG 2-1 by 73.7%. The combination of *T. harzianum* and *Cinnamomum loureirii* stem bark powder reduced the severity of radish damping-off by 80.6%, suggesting that it can be employed for the control of *R. solani* development (Lee et al., 2011).

Islam et al. (2012) evaluated the seed treatment with neem leaf (*Azadirachta indica*), garlic clove (*Allium sativum*), allamanda leaf (*Allamanda cathartica*), ginger rhizome (*Zingiber officinale*), kalijira seed (*Nigella sativa*), bel leaf (*Aegle marmelos*), turmeric rhizome (*Curcuma longa*), katamehedi leaf (*Lawsonia alba*) and onion bulb (*Allium cepa*) against damping-off, seed germination and growth characters of tomato (*Lycopersicon esculentum* L.), eggplant (*Solanum melongena* L.) and chilli (*Capsicum annum*) seedlings. The most effective against seedling damping off was neem leaf extract followed by garlic clove and allamonda. The highest seed germination of tomato seeds (86.67 %) was observed under neem leaf extract effect (Islam et al., 2012).

Therefore, several papers were identified for presenting results in controlling a wide range of tomato soil borne pathogens by different plant products but still very few studies went further to report the efficacy of botanicals against soil borne pathogens in field level (Islam et al., 2012). After reviewing the literature on antimicrobial activity, it can be concluded that the vegetal material is representing an inexhaustible source of biologically active compounds. It was already demonstrated that secondary metabolites of plant origin have practical application in the food industry and (Arsene et al., 2015) and agriculture, for sustainable crop disease management as well.

CONCLUSIONS

Due to international trend for environmentally safe crop production, the modern farmers will have to incorporate innovative pest and disease management approaches to reduce their

dependency on pesticide use. Plant products have shown promising results for the control of soil-borne pathogens. The antifungal and antimicrobial effects are due to synergistic activity of constituents present in plant-based products.

Nevertheless, for using these products with reproducible efficiency, it is important to compare their mode of action for the optimization of the manufacturing process, the stabilization of these preparations, dates and rates of application.

ACKNOWLEDGEMENTS

This work was supported by a grant of the Romanian National Authority for Scientific Research and Innovation, CNCS/CCCDI - UEFISCDI, project number PN-III-P2-2.1-PED-2016-1544, contract number 14PED / 2017, within PNCDI III.

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