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RESEARCH ARTICLE

Antifungal activity and growth promotion of « *Solanum elaeagnifolium* » green compost extract against *Fusarium oxysporum* f.sp. *radicis-lycopersici* the causal agent of *Fusarium* crown and root rot in tomato plants

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A B S T R A C T

Green compost made by the aerobic mesophilic technique (surface composting), prepared entirely of the waste of the invasive plant "*Solanum elaeagnifolium*" was tested to assess its inhibitory implication against *Fusarium oxysporum*f.sp. *radicis-lycopersici* (FORL) the causative agent of tomato (*Solanum lycopersicum*, L.) *Fusarium* crown and root rot (FCRR). Compost extract that has been pure and sterilized (filtered and autoclaved) was tested *in vitro* to examine its inhibitory impact. After 7 days at 28°C, a100% prevention was noticed on PDA medium containing 15% pure green compost extract; however, sterilized compost extracts showed no implication. *In vivo* experiments were conducted on tomato seedlings using dip root inoculations. According to the results, tomato seedlings that had been inoculated and planted in compost-containing substrates resisted FORL. The growth of seedlings inoculated with root dip was longer in substrates containing compost. In addition, when compared to the control group of no-inoculated and untreated plants, the inoculated tomato seedlings treated with compost extract grew taller and had a more robust root system. The current study actually demonstrated that the green compost from "*Solanum elaeagnifolium*" that was tested acted by both chemical composition and microorganisms. It could be used in the right amounts as biological fertilizers and as a biological control against *Fusarium* crown and root rot in tomato plants.

Keywords: Antifungal activity, mycelial growth, *Solanum elaeagnifolium,Fusarium oxysporum* f.sp. *radicis-lycopersici*.

INTRODUCTION

The production of tomatoes is a major part of Algerian agriculture, as it is in many other nations. Nevertheless, this prime is vulnerable to numerous soil borne diseases that are resulting in significant losses. *Fusarium oxysporum* f.sp. *radicis-lycopersici* (FORL) is one of these pests, the fungus that causes *Fusarium* crown and root rot (FCRR), is the most dangerous and challenging to manage (Ramachela *et al*., 2021). Because plant pathogens are becoming more resistant, chemical fungicides are less effective at controlling this type of disease.

Furthermore, synthetic fungicides pollute the environment and pose a serious risk to the health of people, animals and plants (Ozbay and Newman 2004; Daami-Remadi *et al.,* 2006; Avis, 2007; Atiq *et al*., 2022; Usman *et al*., 2024). Actually, in order to control this type of pathogen, new alternatives must be found. Numerous studies have examined the effectiveness of compost and compost extract as a biological control of various soil-borne pathogens (Pharand *et al.,* 2002; Hibar *et al.,* 2006; Shanying *et al.,* 2016; Ros *et al.,* 2020; Merah *et al.,* 2022). They have considerably decreased the prevalence of *Fusarium* crown and root rot on tomato plants *in vivo* (Hibar *et al.,* 2006). Additionally, they have effectively suppressed numerous other phytopathogenic fungi such as *Botrytis cinerea, Alternaria alternata, Pyrenochaeta lycopersici* (Palou *et al.,* 2013; Pane *et al.,* 2012), *Fusarium oxysporum* f.sp. *lycopersici* (Morales-Corts *et al.,* 2018; Bashir *et al*., 2018) and *Rhizoctonia solani* (Nofal *et al.,* 2021).

Nonetheless, the most compost that has been tested is made from a blend of animal manure and plant waste (Dionne *et al.,* 2012; Shanying *et al.,* 2016; Din *et al.*, 2018; Merah *et al.,* 2022), where a few studies concentrate on green compost madeentirely of plant waste. Green waste compost is thought to be safer and more agronomically beneficial than other types of compost (made from animal manure, industrial waste, etc.) when used as organic soil amendments and as a biological control of soil-borne pathogens. These are at high risk of toxicity because theycontain heavy metals, pollutants, microbiological pathogens, etc (Pascual *et al.,* 1999, Masciandaro *et al.,* 2000; Witter *et al.,* 1998).

Using a mesophilic process, the green compost utilized in this study is composed entirely of *Solanum elaeagnifolium* debris plants. The actual goal of this study is to determine whether green compost extract has a positive impact on plant growth by evaluating its effects on FORL mycelium growth in vitro its ability to inhibit *Fusarium* crown and root rot in tomato plants *in vivo.*

MATERIALS AND METHODS

"*Solanum elaeagnifolium"* green compost preparation: Green compost was prepared with 100% of debris plants of "*Solanum elaeagnifolium"* (an invasive plant) according to an aerobic-mesophilic process using "Surface composting" method during the period 2016-2017 at USTO-MB University. Surface composting was carried out with periodical turning (Indore method) over a period of 06 months. The principal chemical, microbiological and biochemical characters are showing in table 1.

Pure compost extract preparation: The pure extract was prepared with aerobic method, according to the steep age procedure of Weltzein (1992) modified by Znaïdi (2002). The green compost was suspended in tap water (1:5 weight/volume) in a loosely covered 05-liter plastic container. The suspension was incubated for 7 days at 15 to 22°C and daily stirred 5 to 10 minutes. Extract was then filtered through a 2 mm screen to remove large particles. After a centrifugation at 8500 rpm for 15 minutes, surfactant was collected in sterile containers and stored at 4°C. Extract was taken out 30 min before use.

Table1. Physical, chemical and microbiological characteristics of "*Solanum elaeagnifolium"* green compost.

Parameters	Values
pH (H_2O, 1:10)	7,4
Electrical conductivity (mS/cm)	3,75
Total organic matter (%)	29,04
Total organic carbon (%)	22,7
Total N (%)	1,57
Total P (%)	0,67
Total K (%)	4.76
Ratio C/N	14,5
Zn (%)	1.59
Fe (%)	7.76
Mg (%)	2.37
Cu (%)	1.28
Ca (%)	1,42
Mn (%)	0,51
Na	0,49
Oxygen	33.56
Fungi (CFU/g)	6,24 x10^5
Bacteria (CFU/g)	8,71 x10^6

Fungal agent: In this study, FORL strain used was isolated in 2013, from tomato plants cultivated under greenhouse from north-west Algeria and showing a high level of pathogenicity based on typical symptoms of *Fusarium* Crown and Root Rot (FCRR) disease. After its macroscopic and microscopic identification, the determination of *forma specialis* of this pathogen was done using pathogenicity test on two different tomato cultivars (Rio Grande and Mont Favet) basing on his sensibility against FORL. Fungal cultures were grown on Potato Dextrose Agar (PDA) medium and incubated at 28°C for 7 days before being used for antifungal assays.

***In vitro* tests: Effect of green compost extract on FORL mycelium growth:**The effect of green compost extract on FORL mycelium growth was measured by individually incorporating: the pure prepared extract, the sterilized extract autoclaved (121°C, 20 min) and micro-filtered extract (0.22 µm) into cooled molten media (PDA) at 15% (v/v) as described by Koné *et al*. (2010) and poured into Petri plates (9 cm in diameter) and allowed to solidify at room temperature.

A mycelium disk of 5 mm diameter was cut out from periphery of actively growing fungus FORL (4-7 days old culture) with the help of a pre-sterilized cork borer and aseptically plated at centre of each Petri plate. Plate without extract (sterilized distilled water) was used as negative control. All Petri plates were incubated at 28°C for 1 week in dark.

After incubation the effect of extract was determined by measuring the radial growth of fungi in test plate and compared with control plate. Colony diameter of fungus in each plate was measured in cm. The antifungal activity was assessed in terms of percentage inhibition. Percentage growth inhibition (%) of FORL was calculated according to the following formula:

Growth inhibition (%) = I % = C-T/C x 100

Where C= Growth of mycelium in control plate (cm) and T=Growth of mycelium in treatment plate (cm) mean of five plates considered as final reading.

Each individual treatment was replicated five. The whole experiment was repeated twice.

***In vivo* tests: Tomato plants:**In this experiment, tomato cultivar used for *in vivo* tests was « Rio Grande » basing on his sensibility against FORL and it is the most cultivated in Algeria (industrial tomato) (ITCMI, 2022).

Green compost extract effect on the expression of tomato disease (*Fusarium* crown and root rot):

Seedling preparation: Tomato seeds of (*Solanum lycopersicum*, L. cv. Rio Grande) were disinfected in absolute ethanol for 5 minutes, and rinsed with sterile distilled water (Benhamou *et al*., 1997). After drying, seeds were placed under sterile conditions in Petri plates on filter papers soaked with sterile distilled water. Seed germination was assessed after 4 days in a growth chamber at 22°C (Hibar *et al*., 2005). The germinated seedlings were transferred to alveolus plates filled with sterilized peat (120°C under pressure of 1 bar for 30 min). They were watered daily and fertilized twice a week with KNOP (K (Potassium), N (Nitrogen), O (oxygen), P (Phosphor)) nutrient solution for rooting (Calcium Nitrate 1g; Potassium Nitrate 0,25g; Magnesium Sulfate 0,25g; Mono-Potassium Phosphate or Dihydrogen Phosphate 0,25g; Iron Sulfate 0,05g; sterilized distilled water 1000ml) (Alvarez *et al.,* 1995).

FORL inoculum solution preparation: The fungal pathogen was cultivated on PDA medium. After 1 week of incubation at 28°C, conidia suspension was scraped from the surface of the medium using a sterile blade and placed in a conical 100 ml tube containing sterile distilled water. The concentration of the microconidia suspension was determined with a Malassez cell and adjusted by dilution to the desired concentration for plant inoculation to obtain a 10^7 conidia /ml (Hibar *et al*., 2006).

Root dip inoculation: After 21 days (stage of 2-3 leaves), plants were removed from their alveolus plates, roots were rinsed with sterile distilled water, then, they were cut at 1cm from the tips, soaked in inoculum solution of FORL spores (10^7 conidia/ml) for 30 min. After inoculation, they are transferred to plastic pots filled with a mixture (1:4) (v/w) of green compost extract and sterilized peat (120°C under pressure of 1 bar for 30 min).

For inoculated (IC) and no inoculated control (NIC), they are putted in plastic pots, filled with 100% of sterilized peat.

Tomato plants (no-inoculated and no-treated) and tomato plants (inoculated only with FORL) were used as controls to compare the activity of green compost extract. Five repetitions were used in each experiment and all treated tomato plants were placed in a growth chamber at 25°C with 12 h photoperiod and daily watered to promote normal growth (Pharand *et al.,* 2002).

the top lengths of the seedlings were measured 30 days following inoculation, and the mean value of five replications was computed (Woo et al. (1996).

The disease severity was recorded on 0 to 3 visual scales, according to Vakalounakis *et al.,* (1999):

0 = no symptoms, 1 = light yellowing of leaves, light or moderate rot on taproot and secondary roots and crown rot, 2 = moderate or severe yellowing of leaves with or without wilting, stunting, severe rot on taproot and secondary roots, crown rot with or without hypocotyls rot, and vascular discoloration in the stem, 3 = dead seedlings.

Disease incidence was determined using the following formula (Song *et al.,* 2004):

Experiments were conducted according to a completely randomized design with five replicates. Each experimental unit consisted of five tomato seeds. The experiments were repeated twice.

STATISTICAL ANALYSIS

Data for every test, both *in vivo* and *in vitro*, were provided using a completely randomized design.

Every treatment was duplicated five times, and the entire essay was duplicated twice. The data were subjected to analysis of variance(ANOVA) using the Student-Newman-Keuls (SNK) mean comparison test (at P ≤ 0.05) and SPSS (Statistical Package for the Social Sciences) version 16.0.

RESULTS

Effect of green compost extract on FORL mycelium growth:

The mycelium growth of FORL was considerably inhibited by pure green compost extract when compared to the untreated control (PDA+ sterilized distilled water). About 100% of the reducing mycelium growth was observed (Figure.1. B). The results of the autoclaving and microfiltering of the green compost extract revealed no inhibition of mycelium growth. The inhibitory effectof green compost extract on FORL hyphal growth was completely eliminated by autoclaving or sterilizing it with micro-filters (0,22μm) (Figure.1. C and D).

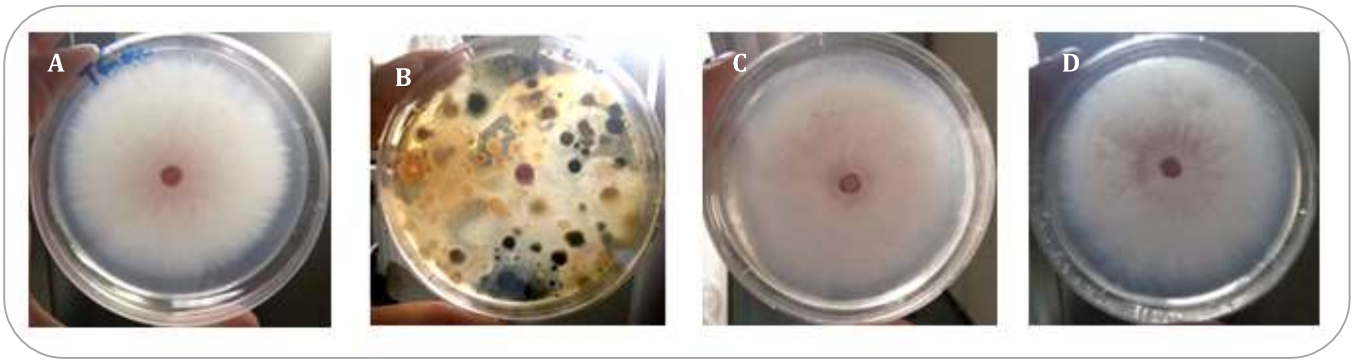

Figure1.FORL colonies grown on PDA medium supplemented with "*S.elaeagnifolium"* green compost extracts, tested at concentration of 15% (v/v) recorded after 7 days of incubation at 28°C. A) Negative control: untreated control (PDA+SDW); B) Pure compost extract; C) filtered compost extract and D) autoclaved compost extract. The highest inhibition (100%) of FORL mycelial growth was recorded to the pure compost extract as compared to the untreated control.

Table2.Showing colony diameter (cm) and growth inhibition (%) of FORL under effect of "*S. elaeagnifolium"* green compost extract (pure, filtered and autoclaved).

PlanCompost extract	FORL colony diameter (cm)	FORL growth inhibition (%)
Pure	0.0	100%
Filtered	8.0	0%
Autoclaved	8.0	0%
Control (SDW)	8.0	0%

SDW:sterilized distilled water

Effect of green compost extract on the disease severity: Disease incidence was noted on tomato plants cultivar "Rio Grande" inoculated with FORL and treated with green compost extract was evaluated 30 days after their inoculation. The addition of green compost extract into the growing substrate has resulted in a significant (*P≤0,05*) suspression of *Fusarium* crown and root rot disease on treated tomato plants as compared to inoculated and non-inoculated control (Figure 3 and Figure 4).

Figure3.Effect of green compost extract on the disease severity: (A) Tomato plants no-inoculated and no-treated; (B) tomato plants inoculated and no-treated (inoculated control); (C) tomato plants inoculated with *Fusarium oxysporum*f.sp. *radicis-lycopersici* and treated with green compost extract.

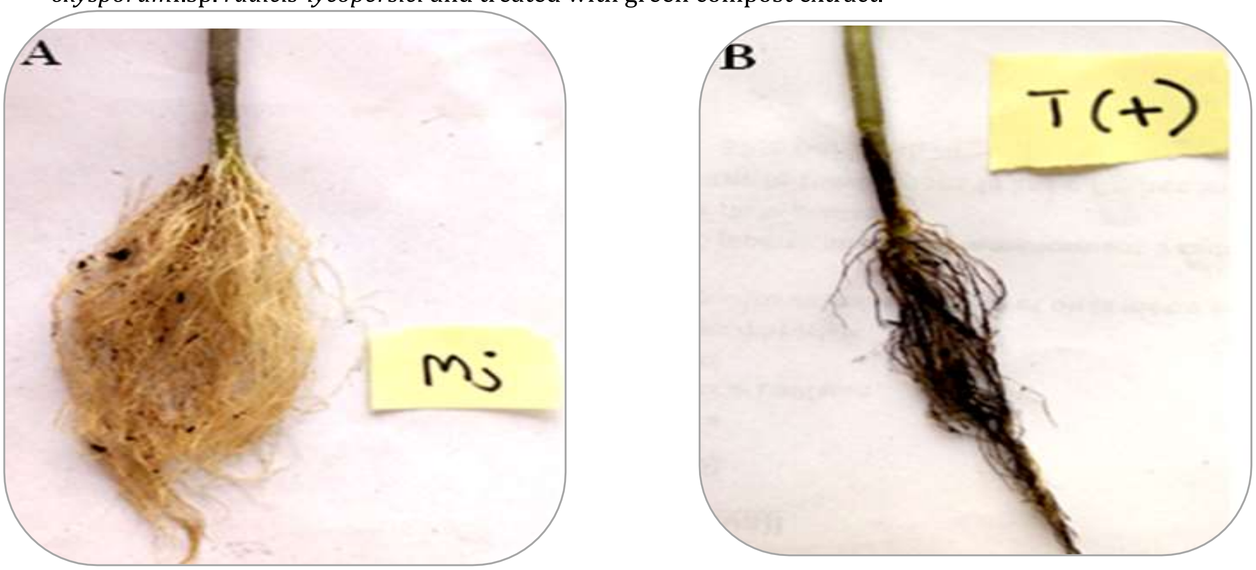

Figure4. Comparison between roots of tomato plant inoculated with *Fusarium oxysporum* f.sp. *radicis-lycopersici* and treated with green compost extract (A) and roots of a control plant (inoculated and no-treated) (B).

The analysis of the root systems of inoculated plants treated with green compost extract, in comparison to inoculated plants that were not subjected to treatment, reveals a significant disparity between the two root systems. The root system of the treated plants exhibits normal growth and appears to be healthy, as though it has not been subjected to inoculation with the pathogen.

The occurrence of disease in plants that were both inoculated and subjected to treatment with green compost extract was approximately 0%, in contrast to the inoculated and untreated control group which exhibited an incidence rate of 80% (Figure4.A).

It should also be demonstrated that the tomato plants which were inoculated andtreated with green compost extract exhibited a vegetative stem length of approximately 27.5 cm, in contrast to the non-inoculated and non-treated control plants, which had a stem length of only about 15.7 cm (Figure3).

The incorporation of compost extract into the plant culture substrate significantly influenced the height of tomato plants. Indeed, the addition of green compost extract to inoculated plants not only provides protection against FORL but also promotesenhanced vegetative growth.

DISCUSSION

The examination of the green compost extract from "*Solanum elaeagnifolium*" against FORL *in vitro* demonstrated a significant inhibitory effect on the growth of pathogen mycelium.

Dionne *et al.* (2012) demonstrated that the teas compost significantly inhibited the growth and proliferation of *Fusarium oxysporum* f.sp. *radicis-lycopersici in vitro*. Numerous prior studies have also indicated the inhibitory effects of compost extract on *Fusarium* spp. (El Kinany *et al.,* 2017; Suárez-Estrella *et al.,* 2012; Akram *et al*., 2018). Similar findings were reported by González-Hernández *et al.* (2021), where teas compost significantly reduced the development of *Rhizoctonia solani in vitro.*

In the current research, the sterilized compost extracts (which were both filtered andautoclaved) did not exhibit any inhibitory effect on the growth of FORL hyphae.These findings align with earlier studies that indicate sterilization typically diminishesthe disease-suppressive ability of composts. El Kinany *et al.* (2017) illustrated in vitro the impacts of both sterilized and unsterilized compost extracts on the mycelialgrowth of *F. oxysporum* f. sp. *albedinis*. It was demonstrated that sterilized extractslose their inhibitory effect on the development of FOA.

Mennai *et al.* (2018) also assessed the *in vitro* inhibitory effects of three compost extracts on the mycelial growth of *F. solani* and *F. oxysporum*. However, the filtration of the tea composts proved ineffective in reducing both pathogens. The impact of compost extracts is linked to the specific community of microorganisms present: it may induce resistance, exhibit antibiosis, or compete for nutrients or space. Sterilization completely removes all beneficial microorganisms, including fungi and bacteria, rendering it ineffective against soil-borne pathogens (Scheuerell and Mahaffee, 2002).

For *in vivo* tests, results showed the efficacy of "*Solanum elaeagnifolium"* green compost extract to suppress *Fusarium* crown and root rot on tomato plants. Several works had showed *in vivo* tests the beneficial effect of compost extract in the suppression of many soil-borne pathogens and specially fungi. Pharand *et al.* (2002) has shown that inoculated plants of tomato with FORL and cultivated in a mixture of peat and compost had significatelly reduce the incidence of the disease compared with incoculated and no-treated plants. Similar results were demonstrated by Hibar *et al.* (2006) and Kerkeni *et al.* (2007), where they have shown that the addition of compost extract to the peat had a benefical effect on inoculated tomato with FORL, where a low symptom of crown and root rot were noted.

The good effect of compost tea prepared from seaweed compost, shrimp powder compost, and chicken, bovine and sheep manure composts, was be demonstrated also by Dionne *et al.* (2012) that it reduces the incidence of the disease caused by FORL on tomato plants. The use of compost teas is one of the most available alternative biological approaches. It is strongly imperative to use it in prevention, controlling or suppression of a wide range of soil-borne plant diseases caused by fungal (Din *et al.*, 2018). Similar results were demonstrated by Shanying *et al.* (2016), where they also demonstrated that vermin compost proved more effective in sustaining the growth of bean and reducing the disease incidence.

Mannai *et al.* (2018) had confirmed that three types of composts composed of variable percents of bovine, ovine; fowl manures, green waste and olive pomace were effective in controlling *Fusarium oxysporum* and *Fusarium solani. In vivo* experiments showed their efficacy in reducing the seedlings root rot. Ros *et al.* (2020) had proved that compost tea extracts from onion waste enriched with *Trichoderma harzianum* practice in intensive cropping systems to enhance crop productivity and quality. Merah *et al.* (2022) had shown also that the addition of compost extract produced by the mixing of 50% of green waste and 50 % of sheep manure to soils contaminated with isolates (*Fusarium acuminatm* and *Fusarium solani*) or the spraying of the compost extract significantly reduced the disease incidence.

In fact, reduce of FORL development by compost extract is probably due to its microbial population and their interactions. The microbial content of green compost used in this study was analyzed previously, where many antagonistic fungi and bacteria were isolated, identified and tested. The principal fungi genera were *Aspergillus, Penicillium* and *Trichoderma*. For bacteria, *Bacillus and Pseudomonas* were the most ones able to inhibit FORL growth. Many studies have shown that the antifungal effect of compost extract is related to its microbial community and specially fungi (Kerkeni *et al.,* 2007a; 2008b; Merah *et al.,* 2022).

Results showed also that the addition of compost extract to growing media had improved tomato plant growth despite the presence of FORL. This development was better than the non-inoculated plants. Similar results were showed by Hibar *et al.* (2006), where tomato plants inoculated with FORL and treated by compost extract has a healthy root system and a better vegetative growth than non-treated plants. In another study, it was demonstrated that the application of compost extract as soil amendment, induce better plant height, heavier fresh root and higher yield of tomato than plants treated with synthetic fungicide (Haruna *et al.,* 2012).

The chemical composition of green compost and its richness on nutriment compounds makes them a good fertilizer for a healthy plants growth (Ros *et al.,* 2020; González-Hernández *et al.,* 2021; Merah *et al.,* 2022). Good effect of green compost extract on tomato plants growth may be also due to the presence of beneficial microorganisms (mostly bacteria) that were known to also promote root growth (plant growth-promoting bacteria) and its richness in inorganic salts, organic carbon and phenols, which can directly affect pathogen growth (Idris *et al.,* 2007; Segarra *et al.,* 2009).

As a consequence, compost amendments can generally augment the development of the micro-flora, boost the soil microbial activity and enhance the competition effects in the soil (Hoitink and Boehm, 1999; Bailey and Lazarovits, 2003)

In the present study, a significant positive correlation was observed between the physical, chemical and microbiological characteristics of "*Solanum elaeagnifolium"* green compost composition and its beneficial effect on plant growth as fertilizer and its capacity to suppress and to protect tomato plants against FORL, proved its use as a biological control of *Fusarium* crown and root rot on tomato plants.

CONCLUSION AND PERSPECTIVES

The present research showed that "*Solanum elaeagnifolium"* green compost extract had a powerful effect in suppression of tomato crown and root rot caused by *Fusarium oxysporum* f.sp. *radicis-lycopersici.* It constitutes a promising alternative for biological control of tomato disease caused by FORL and reduces the abusive use of chemical fungicides that cause environment pollution and having a high risk on humans, animals and plants health. It will be shown also that the use of this kind of compost made from 100% of plant debris, is advantageous and more safety than the other composts,made from animal manure and industrial wastes, which have high risk of toxicity due to the presence of pollutants, heavy metals and pathogen microbial. The suppressed effect of this green compost is probably related to its content on antagonistic microbial (fungi and bacteria). Additionally, the amendment of soil with this green compost as a fertilizer can improve plants growth because of its richness on nutriment compounds.

However, to confirm our results, a future study will attempt the application of green compost under natural conditions to verify its stability and effectiveness.

REFERENCES

Alvarez, M.B., S. Gagné, H. Antoun. 1995. Effect of compost on rhizosphere microflora of the tomato and on the incidence of plant growth-promoting rhizobacteria. Applied in Environnemental Microbiology, 61: 194-199.

Akram, S., S.M. Khan, M.F. Khan, H.U. Khan, A. Tariq, U.U. Umar and A. Gill. 2018. Antifungal activity of different systemic fungicides against *Fusarium oxysporum* f. sp. *lycopersici* associated with tomato wilt and emergence of resistance in the pathogen. Pakistan Journal of Phytopathology, 30(2):

Atiq, M., N.A. Rajput, S.T. Sahi, A. Akram, M. Usman, G.A. Kachelo, H. Ahmad, A.Q. Khan, H. Tariq, S. Ramzan, Z.B. Tahir and M.J. Matloob. 2022. A way forward towards the management of chilli anthracnose -a review. Agricultural Science Journal, 4(1): 1-10.

Avis, T.J. 2007. Antifungal compounds that target fungal membranes: applications in plant disease control. Candian. Journal of Plant Pathology, 29: 323–329.

Bashir, M. R., M. Atiq, Sajid, M., Mohsan, M., Abbas, W., Alam, M. W and Bashair, M. 2018. Antifungal exploitation of fungicides against *Fusarium oxysporum* f. sp. *capsici* causing *Fusarium* wilt of chilli pepper in Pakistan. Environmental Science and Pollution Research, 25(7): 6797-6801.

Bailey, K. L. and G. Lazarovits.2003. Suppressing soil-borne diseases with residue management and organic amendments. Soil Tillage Research, 72: 169-180.

Benhamou, N., P. Rey, M. Cherif, J. Hockenhull, Y. Tirilly.1997. Treatment with the mycoparasite *Pythium oligandrum* triggers induction of defense-related reactions in tomato roots when challenged with *Fusarium oxysporum* f. sp. *radicis-lycopersici*. Phytopathology, 87:108-121.

Din, A. R. J. M., S. Z. Hanapi, S. H. M. Sarip and M. R. Sarmidi. 2018. Disease suppressive effect of compost tea against phyto-pathogens in sustaining herbal plant productivity in: Applied Environmental Science and Engineering for a Sustainable Future, Z. A. Zakaria (ed.). Springer, Publishing, New York, NY.

Dionne, A., J. Russell, H.A. Tweddell, J.A. Tyler. 2012.

Effect of non-aerated compost teas on damping-off pathogens of tomato.Canadian. Journal of Plant Pathololog*y*, 34 (1): 51–57

El kinany, S., E.H. Achbani, A. Haggoud, J. Ibijbijen, S. Belmalha, F. Rachidi, G. Echchgadda R. Bouamri. 2017. *In vitro* evaluation of compost extracts efficiency as biocontrol agent of date palm *Fusarium*wilt. African Journal ofMicrobiology, 11(29): 1155-1161

González-Hernández, A.I., M.B. Suárez-Fernández, R. Pérez-Sánchez, M.A. Gómez-Sánchez, M.R. Morales Corts. 2021. Compost tea induces growth and resistance against *Rhizoctonia solani* and *Phytophthora capsici*in pepper. Agronomy, 11: 781.

Hibar, K., M. Daami-Remadi, H.Jabnoun-Khiareddine, I. El AkramZnaidi, M.E. Mahdjoub. 2006. Compost extract effect on mycelium growth and the aggressiveness of *Fusarium oxysporum* f.sp. *radicis-lycopersici.* Biotechnological Agronomy Society Environment, 10 (2):101-108.

Hoitink, H.A.J. and M.J.Boehm. 1999. Biocontrol within the context of soil microbial communities: a substrate dependent phenomenon. Annual Review of Phytopathology, 37: 427-446.

ITCMI.2022. Culture of industrial tomato. Technical data sheet on market garden and industrial crops. Technical Institute for market garden and industrial crops. Algies, Algeria. www.itcmi-dz.orgIdris

H.A., N. Labuschagne, L. Korsten. 2007. Screening rhizobacteria for biological control of *Fusarium* root and crown rot of sorghum in Ethiopia. Biological control, 40: 97-106.

Kerkeni,A., M. Daami-Remadi, N.Tarchoun and M.B. Khedher. 2007. *In vitro* and *in vivo* suppression of *Fusarium oxysporum* f.sp. *radicis-lycopersici* the causal agent of *Fusarium* crown and root rot of tomato by some compost fungi. International Journal of Agricultural Research, 2 (12): 1022-1029.

Koné, S.B., A. Dionne, R.J. Tweddell, H. Antoun, T.J. Avis. 2010. Suppressive effect of non-aerated compost teas on foliar fungal pathogens of tomato. Biological Control, 52: 167–173.

Mannai, S., N. Benfradj, N. Horrigue-Raouani, N. BoughallebM'Hamdi. 2018,Antifungal activity and growth promotion of three types of compost extracts against *Fusarium oxysporum* and *Fusarium solani* associated with peach seedling decline in nurseries. Journal of Crop Protection, 7 (3): 349-363

Masciandaro, G., B.Ceccanti, C. Garcia. 2000. *In situ* vermin-composting of biological sledges and impacts on soil quality. Soil Biology and Biochemistry, 32:1015-1024.

Merah, F., F. Lazreg, L. Belabid, J. Sanchez, E. Gallego. 2022. Physico-Chemical and Biological Characterization Of The Compost E2 And Their Potential For Suppressing Plant DiseasesPakistan. Journal of Phytopathology, 34 (01):71-80.

Morales-Corts, M.R., R. Pérez-Sánchez, M.R. Gómez-Sánchez. 2018. Efficiency of garden waste compost teas on tomato growth and its suppressiveness against soil borne pathogens. Soils and Plant Nutrition, 75: 400-409.

Nofal, A.M., M. Abd El-Rahman, A.A. Alharbi and T.M. Abdelghany. 2021. Ecofriendly Method for Suppressing Damping-off Disease Caused by *Rhizoctonia solani* Using Compost Tea. Bio Resources, 16: 6378-6391.

Ozbay, N., S.E. Newman. 2004. *Fusarium* crown and root rot of tomato and control methods. Plant Pathology Journal, 3: 9-18.

Palou, L., V. Taberner, A. Guardado, M.Á. Del Río, C. Montesinos-Herero. 2013. Incidence and etiology of postharvest fungal diseases of pomegranate (*Punicagranatum* cv. Mollar de Elche) in Spain. Phytopathology of Mediterrany,52:478-489.

Pane, C., G. Celano, D. Villecco, M. Zaccardelli. 2012. Control of *Botrytis cinerea*, *Alternariaalternata* and *Pyrenochaeta lycopersici* on tomato with whey compost-tea applications. Crop Protection, 38:80-86.

Pascual, J.A., C. Garcia, T. Hernandez. 1999. Lasting microbiological and biochemical effects of the addition of municipal solid waste on an arid soil. Biology and Fertility of Soils, 30: 1-6.

Pharand, B., O. Carisse, N. Benhamou. 2002. Cytological aspects of compost-mediated induced resistance against *Fusarium* crown and root rot in tomato. Phytopathology, 92: 424–438.

Ros, M., M. Hurtado-Navarro, A. Giménez, J.A. Fernández, C. Egea-Gilabert, P. Lozano-Pastor and J.A. Pascual. 2020. Spraying agro-industrial compost tea on baby spinach crops: Evaluation of yield plant quality and soil health in field experiments.

Agronomy, 10: 440.

Scheuerell, S. and Mahaffee, W. 2002.Compost tea: principles and prospects for plant disease control. Compost Science & Utilization, 10: 313-338.

Segarra, G., M. Reis, E. Casanova, M.I. Trillas. 2009. Control of powdery mildew (*Erysiphepolyony*) in tomato by foliar applications of compost tea. Journal of Plant Pathology, 91: 683-689.

Shanying, H., L. Anan and L. Wang. 2016. Effect of Sewage Sludge and its Biomass Composting Product on the Soil Characteristics and N2O Emission from the Tomato Planting Soil. International journal of Agriculture and Biology, 18: 501-508.

Son, W., L. Zhou, C. Yang, X. Cao, L. Zhang, X. Liu. 2004. Tomato *Fusarium* wilt and its chemical control strategies in a hydroponic system. Crop protection, 23:243-247.

Suárez-Estrella, F., Bustamante, M. A., Moral, R., Vargas-García1, M. C., López, M. J. and Moreno, J. 2012. *In vitro* control of *Fusarium* wilt using agro-industrial sub-product-based composts. Journal of Plant Pathology, 94: 59-70.

Ramachela, K., Mpaneng, M.A., Mathuthu, M. and Zeevaart, J.R., 2021. Response of *Fusarium oxysporum* f. sp. *radicis-lycopersici* (FORL) to znno 3 under *in vitro* conditions. Pakistan Journal of Phytopathology, 33(1).

Usman, M., M. Atiq, N.A. Rajput, S.T. Sahi, M. Shad, N. Lili, S. Iqbal, A.M. Arif, U. Ahmad, K.S. Khan, M. Asif, F.U. Haider. 2024. Efficacy of Green Synthesized Silver Based Nanomaterials against Early Blight of Tomato Caused by *Alternaria solani*. Gesunde Pflanzen, 1-11.

Vakalounakis, D.J., G.A. Fragkiadakis. 1999. Genetic diversity of *Fusarium oxysporum* isolates from cucumber: differentiation by pathogenicity, vegetative compatibility and RAPD fingerprinting. Phytopathology, 89:161-168.

Witter, E., J. Lopez Real. 1998. Nitrogen losses during the composting of sewage sludge, and the effectiveness of clay soil, zeolite, and compost in adsorbing the volatilized ammonia. Biological Wastes, 23:279-294.

Woo, S.L., A. Zoina, G. Del Sorbo, Lorito, B. Nanni, F. Scala, C. Noveiello.1996. Characterization of *Fusarium oxysporum* f.sp. *phaseoli* by pathogenic races, VCGs, RFLPs, and RAPD. Phytopathology, 86:966-972.

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Aicha Bouras	:	Conduct research and wrote manuscript
Ryme Terbeche	:	Review of literature