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PHYSICO-CHEMICAL AND BIOLOGICAL CHARACTERIZATION OF THE COMPOST E2 AND THEIR POTENTIAL FOR SUPPRESSING PLANT DISEASES

[a]Fatima Merah*, [a]Fatiha Lazreg, [a]Lakhdar Belabid, [b]Jose Sanchez, [c]Edwardo Gallego

[a] *Department of Agronomy, Laboratory of Research on Biological Systems and Geomatics, Faculty of Natural Sciences and Life, University of Mascara, 29000 Mascara, Algeria.*
[b] *Botany Unit, Department of Biology and Geology, University of Almeria, E-04120 Almeria, Spain.*
[c] *Botany Unit, Department of Biology and Geology, University of Almeria, E-04120 Almeria, Spain.*

A B S T R A C T

Composting is a natural degradation process of organic matter. Thus, this practice is promising in terms of economy and environment. Another intriguing aspect of this practice is the protection of plants from fungal diseases. The ultimate goal of this study is to check the efficacy of the compost and their potential for suppressing plant diseases. Our product (E2) has been produced by the mixing of 50% of green waste and 50 % of sheep manure. In addition, Trichoderma sp was supplemented to improve the value of this biological alternative in agriculture. On the other hand, we have also produced the compost extract for two main purposes; the former is to evaluate the physicochemical and biological proprieties, the latter is to examine their effect in controlling pathogenic fungi (*Fusarium solani*, *Fusarium acuminatum*, Alternaria sp) *in vitro* and *in vivo*. The biological analysis of our compost has clearly demonstated different genres of microbial population in our compost. In physicochemical test, we have also recorded a good biodegradation of organic matter, an alcaline value of pH and a richness of humic and fulvic acids. Then the presence of fertilizing elements has followed. The mediums were prepared from the compost extract with glucose autoclave and without glucose autoclave-free at 120°C and 80°C. After that, they were tested on biological characters in vitro of the fungi tested. Both medias have depicted significant results in inhibiting the mycelial growth, sporulation and the germination on the tested pathogens. The medium of compost extract without glucose resulted maximum inhibition in mycelial growth by (90%), sporulation and spore germination by (85%).To evaluate the effect of compost and their extract in vivo for the protection of tomato plants from fungal diseases, of 50% from the compost E2 was added to the substrate contaminated by the telluric pathogen (*Fusarium solani* and *Fusarium acuminatum*). Such addition has manifested the minimization of the disease incidence up to 25% compared to the control. Similar result has been observed for the leaf disease (Alternaria sp). As a final vital remark, preventive control by compost extract is the best method to reduce the foliar disease incidence compared with the curative control.

Keywords: biological characters, compost, fungal diseases, incidence, protection.

INTRODUCTION

Composting is a long-time used technology, yet it has some shortcomings related to reducing its extensive usage and efficiency. This process entails controlling the conversion of degradable organic products and wastes into stable products through the agency of microorganisms (Ayilara *et al.,* 2020), however, composting, as probably the only method of waste treatment (Sulewski *et al.,* 2021). Composting has become a favorable option to treat organic wastes for obtaining a finished stable sanitized product. This latter can be used as an organic amendment (Sayara *et al.,* 2020). Compost is one of nature's best mulching and soil amendment materials. Moreover, it is one of the most effective methods in recycling organic waste. To a great degree, it enables obtaining a valuable organic fertilizer. This fertilizer is a substrate of humus that can be applied among others, in crop

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* Corresponding Author:
Email: fatima.merah@univ-mascara.dz

production for consumption purposes. Another aspect of the application is the organic waste products. They are turned into composts that are economically and ecologically valuable. Furthermore, they are regarded to be environmentally friendly (Rdziemska and Zbigniew, 2015; Iqbal and Azeem, 2021; Zahid *et al.,* 2022). According to Al-Rumaihi *et al.* (2020) compost is an amendment that is fundamental in the management of waste and reduction of preventable emissions associated with food waste. Additionally, Plant pathogens and diseases are also resistant to chemical insecticides. As such, compost is a biological alternative. It can be utilized for recycling and valorization of organic wastes. On this account, it marks potential in sustainable agriculture. Santhanarajan *et al.* (2021) concluded that a good establishment of the functional microbes within the composts contributes to the biocontrol of the pathogens in the soil environment. The suppressive effect of compost on damping-off disease was declared at a concentration of 30% tea compost filtrate inhibited 87.0% of *Rhizoctonia solani* population and it was completely inhibited at a concentration of 50% (Nofal *et al.,* 2021). Morales-Corts *et al.* (2018) evaluated in vitro and in vivo tests the suppressive effect of compost on *Rhizoctonia solani and Fusarium oxysporum* f.sp. *Lycopersici*. This body of literature showed that the compost suppressed fungal diseases, so the efficiency of compost is increased when it is supplemented with *Trichoderma harzianum* (Ros *et al.,* 2020). Recently, researchers have shown that compost application has multiple positive effects, which in turn affect each other. The addition of organic amendments increased organic matter, cation exchange capacity, the grain yield (up to 51%) (Oueriemmi *et al.,* 2021). Therefore, composting is a simple and rapid process compared to other technologies. It can represent an alternative; highly viable in managing organic waste (Rastegari Kopaei *et al.,* 2021). Moreover, the physicochemical characterization has proved that these composts are of good quality, rich in nutrients and particularly N, P, K, Ca, Mg, and Fe, and conforms to the standards of an organic amendment (Majbar *et al.,* 2018).

Fungal diseases are amongst the most serious problems of our cultures, in this study we have tested two types of fungal diseases such as, soil borne Diseases (*Fusarium solani, Fusarium acuminatum*) causing root rot and damping-off. These are the most important pathogens, foliar Disease (*Alternaria* sp) causing black spots at the leaves.

Our leading objectives were to study the physico-chemical and biological characteristics of compost E2 from green waste, sheep manure with the addition of *Trichoderma* sp*.* The other overall goal of the study was to determine their effect on pathogenic fungi with *in vitro* and *in vivo* tests. These studies were to confirm that it can be used as soil conditioner in agriculture to improve plant health and to protect the environment.

MATERIALS AND METHODS

The compost Production: This study was carried out at the experimental farm of Mascara University during the period 2016-2017 with different compositions, in which conditions were under control (temperature and pH). The aeration of the mixture was undertaken every 15 days. Our compost (E2) was produced by mixing 50% green waste, 50% sheep manure with the addition of *Trichoderma* sp. The humidity was carefully set at 70% for the mixture.

Microbial determination of the compost: To determine the microbial population in our compost, we followed the technique described by Rapilly (1968) through the agency of suspension-dilution. One gram of compost was added to 10 ml of sterile distilled water to prepare solution mother. A series of suspension-dilution were prepared then 1ml from each concentration 10^{-2} and 10^{-4} was cultured on the media of PDA and MEA within three replicates. The cultured petri dishes were incubated at two different temperatures 25°C and 30°C for one week. The determination of the fungal colony was made by counting the colonies and the results are expressed by the UFC (Units Forming Colonies)/ g of compost (Mouria *et al.,* 2012). The macroscopic and microscopic identification of manifested isolates was based on (type of mycelium, colony size, shape, conidia, presence and the absence of conidiophore) by using the key of Rémi *et al* (1997), and the isolation frequency of the identified species was calculated.

Physical and chemical analysis of compost: Preparation of compost extract: The extraction of compost E2 was prepared using the method of Koné *et al.* (2010). To obtain a compost extract from compost E2, 100g of compost was mixed with 400ml of sterile distilled water in 1-L Erlenmeyer flasks at a weight to volume ratio of 1 to 5. (W: v). the mixture was homogenized in the dark for14 days at 25 °C in an orbital shaker at 150 rev/min. Then, the mixture was loosely covered at the same temperature (25°C for 14 d in the dark) the mixture was extracted. Afterwards, the compost extract was stored in the refrigerator at a temperature of 4°C.

A compost extract was prepared to study their physical and chemical proprieties analysis (pH, conductivity, dry matter, organic matter). The chemical analysis of compost was completed at the Laboratory of Analysis (Primary Analysis Service) at the University of Almeria Spain. The compost sample (E2) was analyzed for quantitative determination of B, Cr, Mn, Fe, Ni, Cu, Zn, As, Mo, Cd, Pb and Hg by using ICP-MS model X series 2 brand Thermo Scientific. To determine elementary composition by Fluorescence with X-rays 5 g of the sample was analyzed using the method of FastVac-34 with Bruker pioneers X-ray fluorescence spectrometry device.

Effect of compost extract on Mycelia growth, sporulation and spore germination *in vitro* Fungi isolates: Isolates comprised *F. acuminatum* (F25RS3) with Genbank Accession (JX114790) and *F. solani* (F20ST) with Genbank Accession (JX114796) were identified by Dr Lazreg at the Laboratory of Research on Biological Systems and Geomatics, Department of agronomy, University of Mascara. These isolates were tested for their pathogenicity and polyphagy (Lazreg *et al.,* 2014**).** The isolate of *Alternaria* sp was isolated from infected potato leafs at the laboratory of Laboratory of Research on Biological Systems and Geomatics.

To determine the effect of the compost extract on these pathogenic, fungi explant of 0.8 of each isolate were placed into the center of petri dishes containing media prepared from the compost extract with three replicates for each isolate. The plates were incubated at 25˚C. After 7 days of incubation, the percentages of Mycelia growth inhibition and sporulation inhibition were measured using the adopted method of Mouria *et al.* (2013). The spore germination was also analyzed using the method of Rapilly (1968). The control was tested on PDA medium without compost.

Effects of compost and their extract on soilborne diseases and foliar disease *in vivo:* Plant material: Tomato seeds belonging to the Suzana Hybride F1 variety were tested on the basis of its sensitivity to *Fusarium* sp.

Isolate inoculum was produced using the modified protocol of Kirkapatrick (2006). Suzana Hybrid F1 33 tomato seeds were superficially disinfected with 1% diluted sodium hypochlorite, and then rinsed abundantly with SDW. To test the effectiveness of compost on disease suppression, 10 seeds were grown in pots containing soil contaminated with each isolates of *Fusarium,* and mixed with compost at a concentration of 50% with three replicates for each isolate, for the positive controlwere achieved by growing seeds in contaminated soil (*F. Solani, F. Acuminatum*), without compost, the negative control was carried out in a sterile soil. The pots were incubated in a greenhouse and irrigated every 2 days.

For the foliar treatment, we studied the effect of the compost extract in two cases:

Preventive test: the pots were sprayed with the compost extract (E2) until saturation, after that, they were incubated at the ambient temperature, after 2 days of incubation the pots were sprayed with a suspension sporal of *Alternaria* sp (with three replicates). Subsequently, the seedlings were incubated again under the same previous conditions.

Curative test: the pots were inoculated with the pathogen (with three replicates), after 2 days of incubation the pots were sprayed by the compost extract. After that, they were incubated at the ambient temperature of the experimental greenhouse farm. Then, were irrigated every 2 days. Plant protection was assessed by calculating the percentage of inhibition of the disease compared to the untreated control by compost extract. In the positive control, the pots were sprayed by the pathogen (suspension sporal of *Alternaria* sp). Following this, the pots were sprayed by sterile distilled water for the negative control. The diseases incidence was evaluated and calculated using the formula of Menzies *et al.* (2005).

STATISTICAL ANALYSIS

Data were analyzed using two ways; ANOVA and significant differences between treatment means were compared by Tukey's HSD test. XL Statistica 8.0 software was used for data analysis"

RESULTS

Biological analysis of the compost: The microbial population in our compost indicated a clear differentiation and was influenced by the medium (PDA, MEA) and the temperatures incubation (25ºC, 30ºC), five species of fungi belonging to 04 genera were isolated and identified (Table 01). The current study confirmed that there was a significant difference in the appaerance of different isolates. These differences were observed on different medias at varying temperatures (df=4; F=12.20; P=1.79). The *Aspergillus* sp appaered on PDA and MEA with 0.67 and 1.02×10^4 cfu/g respectively at the temperature 25ºC. Respectively, it was 1.22 and 1.76×10^4 cfu/g in both medias at 30ºC temperature. *Trichoderma harzianum* was recorded with $1,22\times10^4$ cfu/g and $0,12\times10^4$ cfu/g on PDA medium at 25ºC and 30ºC respectively. On MEA medium, the *Trichoderma harzianum* was counted at 0.65×10^4cfu/g and 0.85×10^4cfu/g respectively at 25ºC and 30ºC.On the other hand, *Fusarium sp*, *Penicillium sp* and *Mucor sp*appreared on PDA and MEA meduims with 0.15×10^4cfu/g to1.72×10^4cfu/g at temperatures 25ºC and 30ºC respectively.

Table 1. Fungal density (CFU/g MS) in the compost E2 on PDA and MEA medias at different temperatures.

Microbial population	Fungal density (x10⁴ CFU/g MS)			
	PDA		MEA	
	25ºC	30ºC	25ºC	30ºC
Trichoderma harzianum	1.22 ± 0.005[abcde]	0.12 ± 0.011[f]	0.65 ± 0.023[def]	0.82 ± 0.023[bcdef]
Mucor sp.	0.15 ± 0.011[ef]	1.76 ± 0.11[ab]	1.43 ± 0.075[abcd]	1.7 ± 0.023[abc]
Fusarium sp.	0.84 ± 0.028[abcdef]	0.22 ± 0.023[ef]	0.54 ± 0.028[def]	0.15 ± 0.023[ef]
Penicillium sp.	0.54 ± 0.01[def]	0.51 ± 0.007[def]	0.80cdef ± 0.02[cdef]	1.66 ± 0.02[abc]
Aspergillus sp.	0.67 ± 0.01[def]	1.22 ± 0.05[abcd]	1.02 ± 0.09[abcdef]	1.76 ± 0.02[a]

The physicochemical analysis: The results on physicochemical analysis of our compost were demonstrated in the Table 02, pH is considered as an important parameter in controlling the degradation process in composting, for which pH forms an important criteria of consideration, pH value of our compost E2 was 8.58 indicating that it was alkaline value, Electricity conductivity (EC) was 4,31 mS/cm. The percentage of the organic matter was 12.02%, the dry matter was 88.89%. Moreover, the humidity during the composting process was 3.80%. The humic and fulvicacids were important parameters in determining compost maturity, the humic acid was 3.5 % and fulvic acid was 6.6 %, on the total scale of humicacids, it was 10.1%.

Phosphorous (P) is considered as the essential nutrient in compost. It was recorded 0.655%. The potassium (K) is essential for the sustainability of crop productivity, it was about 7.214%. The comparison of higher nutrient content in our compost (E2) might indicate an intense biodegradation process, the concentration of heavy metals were observed with different values. The total concentration of micro nutrients (Na, Ca and Mg) were respectively illustrated in the Table 02 with 0.541, 6.473 and 0.9681%. Furthermore, the contents of trace elements were: cadmium (Cd) with 0.19%., nickel (Ni) with 8.78%, zinc (Zn) with 69.22%, chromium (Cr) with 17.77%, manganese (Mn) with 151.79% and copper (Cu) with 13.68%.

Effect of compost extract on mycelia growth, sporulation and spore germination: The results presented in tables (03, 04, 05) showed that the compost extract inhibited significantly the mycelia growth of the different isolates fungi (*F. solani, F.acuminatum* and *Alternaria* sp) with (df=; f=; p=). The highest inhibition growth percentage was noted on the media prepared from compost extract without glucose and sterilized at temperature 120°C. The inhibition was 90%, 80 %, 84 % respectively for *F.acuminatum*, *F. solani* and *Alternaria* sp.

The inhibition percentage of mycelia growth on compost extract medium of glucose-free sterilized at 120°C, 80°C was significantly more important than the compost extract medium with glucose where the inhibition of mycelia growth was substantial.

In similar fashion, these medias had a significant effect on the fungi sporulation with (df=3; F=18.27; P=2.16). The highest sporulation inhibition was recorded for the isolates *F. solani*, *Alternaria* sp, on compost extract medium without glucose sterilized at120°C. Nevertheless, effects of compost extract medium without glucose sterilized at 80°C and 120°C inhibited the sporulation with 75%, 85% of *F. solani*, *Alternaria sp* respectively.

The spore germination of our isolates were significantly inhibited by these different medias

With (df=3; F=26.19; P=9.58). The highest inhibition was recoreded for the isolate *F. Acuminatum.* Although, the compost extract medium sterilized at 120°C without glucose inhibited the isolate *F. Acuminatum* with 85%.

Table 2. Physicochemical analysis of compost E2.

Formula	Concentration	Stat,Dev,1	Formula	Concentration	Stat.Dev . 1
Na2O	0.73	0.008	O	25.34	
MgO	1.605	0.0077	Na	0.541	0.0059
AI2O3	5.526	0.023	Mg	0.9681	0.0046
SiO2	29.6	0.058	Al	2.925	0.012
P2O5	1.5	0.014	Si	13.84	0.027
SO3	1.25	0.01	P	0.655	0.0061
CI	3.314	0.017	S	0.502	0.0042
K2O	8.69	0.02	Cl	3.314	0.017
CaO	9.058	0.024	K	7.214	0.016
TiO2	0.405	0.0054	Ca	6.473	0.017
Cr2O3	0.0038	0.0003	Ti	0.243	0.0032
MnO	0.613	0.0014	Cr	0.0026	0.00021
Fe2O3	3.458	0.0077	Mn	0.0475	0.0011
ZnO	0.00488	0.00014	Fe	2.418	0.0054
Br	0.014	0.00039	Zn	0.00392	0.00011
SrO	0.0209	0.00035	Br	0.014	0.00039
ZrO2	0.0873	0.00091	Sr	0.0177	0.00029
			Zr	0.0647	0.00067
Total	65.32818		Total	64.58352	
pH	8.58		MS %	88.89 %	
CE	4.31 mS/cm		MO %	12.02 %	
AH %	3.5 %		H %	3.80 %	
HT %	10.1		AF %	6.6 %	
Cd	0.19		Pb	18.12	
B	27.67		Cr	17.77	
Mn	151.79		Fe	7.70	
Ni	8.78		Cu	13.68	
Zn	69.22		As	2.69	
Mo	1.96		Hg	1.27	

Table 3. Effect of compost E2 on Mycelia growth

Compost extract medias	*F.Solani*	*F.acuminatum*	*Alternaria* sp
CE2G80°C	55% ± 0.06^{c}	65b% ± 0.05^{d}	60% ± 0.04^{c}
CE2G120°C	60% ± 0.02^{bc}	72% ± 0.01^{b}	65% ± 0.02^{abc}
CE2WG80°C	75% ± 0.03^{ab}	82% ± 0.04^{ab}	75% ± 0.02^{ab}
CE2WG120°C	80% ± 0.01^{a}	90% ± 0.02^{a}	84% ± 0.01^{a}

Table 4. Effect of compost E2 on sporulation

Compost extract medias	*F.Solani*	*F. acuminatum*	*Alternaria* sp
CE2G80°C	59% ± 0.05^{de}	55% ± 0.02^{e}	66% ± 0.03^{bcde}
CE2G120°C	65% ± 0.02^{bcde}	69% ± 0.005^{abcde}	62% ± 0.01^{cde}
CE2WG80°C	75% ± 0.01^{abc}	70% ± 0.02^{abcde}	65% ± 0.02^{bcde}
CE2WG120°C	75%^{abc} ± 0.01	72%^{abcd} ± 0.01	80%^{ab} ± 0.05

Table 5. Effect of compost extract on spore germination

Compost extract medias	*F. Solani*	*F. acuminatum*	*Alternaria* sp
CE2G80°C	70% ± 0.08^{abcd}	50% ± 0.05^{d}	55% ± 0.02^{d}
CE2G120°C	60% ± 0.02^{cd}	55% ± 0.02^{cd}	65% ± 0.02^{bcd}
CE2WG80°C	85% ± 0.05^{ab}	90% ± 0.02^{a}	85% ± 0.05^{ab}
CE2WG120°C	69% ± 0.02^{abcd}	85% ± 0.05^{ab}	80% ± 0.02^{abc}

Suppressive effect of the compost and their extract (E2) on soil born and foliar diseases: An increasing body of literature opprobate that the application of compost improves soil properties as it increases soil organic matter and humic substances. The addition of compost in both lots containing soil contaminated with the both isolates (*Fusarium solani* and *Fusarium acuminatum*) with a concentration of 50% had a strong positive effect on the disease decline (root rot) compared with control + (contaminated soil).

From the results presented in (Table 06), the lowest value of disease incidence was observed for *F. acuminatum* with 25%. The development of the root system was noted in plants inoculated (*F. acuminatum*, *F. solani*) and treated with compost (E2). Compared with plants inoculated with the pathogens and transplanted into the substrate without compost. However, the diseases incidences of *F. solani* and *F. acuminatum* without compost were respectively 70% and 75%.

From our result, it is evident that the addition of compost extract reduced the foliar disease incidence of tomato plant (2-3 leaf stage) inoculated with *Alternaria* sp (Table 07), the sprayed plants with the compost extract indicated a significant difference in the methods of treatments (df=1; f=24; p= 0.001). Clear differentiation was influenced by the type of treatment (preventive control, curative control).

In the preventive control, decrease of the foliar disease was caused by (*Alternaria* sp) with 22 % compared to the control where the disease incidence was 80%.

The obtained results indicated that the leaf sprayed by the compost extract was totally suppressed. The symptoms caused by *Alternaria* sp. However, the preventive control by compost extract proved to be the best method to reduce the foliar disease incidence compared to the curative control.

Table 6. Effect of compost E2 on soil born diseases.

Soil borne Diseases (pathogenenic fungi)	% disease incidence with compost
Fusarium solani	35% ± 0.015^{c}
Fusarium acuminatum	25% ± 0.011^{d}

Table 7. Effect of compost extracts E2 on foliar disease.

Foliar diseases (pathogenenic fungi)	*Alternaria* sp
% Disease incidence with compost extract (preventive test)	22% ± 0.011^{c}
% Disease incidence with compost extract (curative test)	30% ± 0.011^{b}

DISCUSSION

The aim of our study was to analyze the physic-chemical and biological characteristics of the compost E2. Notwithstanding, in the present research, we determined the microbial abundance in the compost. Our results are constituent with those found by Atalia *et al*. (2015). The microorganisms which were isolated from our compost on the two media PDA and MEA were *Aspergillus* sp, *Penicilium* sp, *Fuswharium* sp and *Trichoderma harizanium.* The microorganisms responsible for biological degradation in composting are bacteria, actinomycetes and fungi of mesophilic and thermophilic groups (Atalia *et al.,* 2015).

Termorshuizen *et al.* (2005) added that the rate of fungi decomposes the organic matter into a stable amendment for improving soil quality and fertility. The presence of *Trichoderma harzanium* in our compost was a good indicator for biological control. As suggested by Hibar *et al.* (2005). However, Abdel-Ghany *et al.* (2019) stated that the culture filtrates of *Trichoderma harzianum* gradually inhibited the radial growth of *Alternaria solani* at higher concentrations. Therefore, this biological control agent was also found to be effective and environmentally friendly. Moreover, microorganisms are an important parameter for stimulation of plant growth and biological control agents by the compost amendment (Mouria et al., 2010). On the other hand, the treatment with compost and their extract had a strong positive effect on the microbial community including *Trichoderma* species (Termorshuizen *et al.,* 2005).

Epelde *et al.* (2018) confirmed that composted intensive cow manure depicted the highest values of microbial activity. Due to its low content of potentially health-threatening contaminants combined with its highest quality, as reflected by the Amendment Quality Index, it has shown promising potential and thus could be used as a powerful amendment for agricultural use.

The pH is the most important affecting microbial succession and activity during composting (Harada *et al.,* 2020). In the present study, pH was 8.58 indicating that it was alkaline value, Solaiman *et al.* (2019) and Ruíz-Sagaseta *et al.* (2021) reported a similar value of pH, the initial pH value of bio waste before composting was more than 10. In the beginning of the process, the pH decreased, it is the acidogenic phase. It could be explained by the production of organic acids. Dissolved CO2 in the medium and by products from the degradation of easily biodegradable compounds (Tognetti *et al.,* 2007). The second phase is the pH increase; it is the ammonia production from the degradation of amines. Finally, the pH had decreased progressively and stabilized, to an alkali pH which we found in our result. The key contribution of these results suggest the formation of humic substances as confirmed by Majbar *et al.* (2018).

The results of electrical conductivity are in accordance with earlier findings of Agani *et al.* (2015). Therefore, the increase of EC revealed the extent of mineralization of the organic substrate and the release of ions (El Fels *et al.,* 2014). Usually a higher value of EC could be an indication of high nutrient elements presence, or a slower decomposition of the organic matter. Eventually, a lower release of mineral salts into the solution in the process of composting (Harada et al., 2020). However, Ruíz-Sagaseta *et al.* (2021) also found that all the organic fertilizers in his study had a high rate of EC which can be explained by their high nutrient concentrations, especially N-NH 4, K and P.

The evolution of the organic matter is considered an essential parameter of biodegradation and transformation during the composting process, our findings were characterized by a low value of organic matter (12.02%), and this decrease highlighted a good degradation. a decrease in the volumes of composted waste was observed. It is interesting to note that similar results were observed by Majbar *et al.* (2018), indicating that the organic matter decomposition was the result of the microbial activity, in order to obtain a stable humic substances. Rahel *et al.* (2013) reported a similar value of the dry matter compared with our result (88, 89), this result was also an indicator of compost maturity.

Many authors have been studying the humified organic matter or humic substances due to the humification processes. The chemical fractioning of organic matter in humin, humic, and fulvic acids led some authors to develop maturity indicators. Azim *et al.* (2017) studies showed that the composting process involves the formation of fulvic acids (FA) as an intermediate step in the formation of humic acids (HA) and, finally, insoluble, non-phytotoxic humic substances, the amendment of the soils by compost improved the contents in HA, AF as well as the parameters of humidification. Moreover, the application of compost is effective in improving the stability of humic matter and the structure of the soil (Masmoudi. *et al.*,2017; Solaiman *et al.*,2019).

Phosphorous (P) and potassium (K) are always considered as the essential nutrients in compost. By contrast, the results from Meunchang *et al.* (2006) suggest that an amount of P and K were applied as fertilizer to the soil. It is likely that under these conditions P and K from compost increased plant growth. Moreover, the addition of compost improved biodegradation when augmenting soil nutrient content and microbial activity (Uyizeye *et al.*, 2019).

The contents of heavy metals were compared with the results of Ayari *et al.* (2015) our analysis showed that they marked a timid presence. As a limitation, higher values of metals caused a delay in germination, and inhibited plant growth (Tiquia *et al.,* 2010). On top of that, Lasaridi *et al.* (2018) added that composting is considered an effective treatment tool to eliminate or considerably reduce potential of heavy metals, instability and further pathogenic potential.

The compost extracts inhibited the mycelia growth, sporulation and germination of the tested pathogens (*F.acuminatum, F. solan* and *Alternaria* sp). The inhibition was the highest in the compost extract medium without glucose sterilized at 120°C. Our findings found clear support with that demonstrated by Mouria *et al.* (2013). Their findings manifested that the mycelia growth and sporulation of the five selected strains were inhibited by the extracts with 95.24% and 100%. On the other hand, González-Hernández et al. (2021) showed that the teas compost contributed significantly *in vitro* to block the development and proliferation of *R. solani* growth. The obtained results in our research could provide new insights into the fact that our compost (E2) had a suppressive effect on the three isolates. In similar line, it encouraged plant development as put forward in another studies (Ros et al., 2020; González-Hernández *et al.,* 2021).

The addition of compost E2 to soils contaminated with isolates (*F. acuminatm* and *F. solani*) or the spraying of the compost extract significantly reduced the disease incidence. The vermin compost proved more effective in sustaining the growth of bean and reducing the disease incidence (Shanying *et al.* 2016). By the same token, Sahar *et al.* (2013) revealed that disease incidence was 18.3 % of CTP (compost-treated plants) compared with 58.9 % of non-CTP. Ros *et al.* (2020) proposed that compost tea extracts from onion waste enriched with *T. harzianum* can be used in a sustainable agriculture and practice in intensive cropping systems to enhance crop productivity and quality.

One of the available alternative biological approaches is the compost teas. It is strongly imperative to use it for the prevention, suppression, or controlling a wide range of soilborne plant diseases especially those caused by fungal (Din et al. 2018). Moreover, the contribution of composts could also reduce the soil-plant transfer of abundant heavy metals in soil, which is crucial to the health of populations consuming vegetative products (Kitabala *et al.,*2016).

CONCLUSION AND RECOMMENDATIONS

Although further investigations are needed, the present study contributes to a better understanding of the biological and physicochemical analysis of our compost (E2) and their potential for suppressing plant diseases. In similar fashion, it revealed a clear abundance of microbial population. In addition, it shed light on an important biodegradation of organic matter. Furthermore, it pointed out at an alcaline value of pH. The richness of humic and fulvic acids were also considered in the present study. The vitro test confirmed the inhibitory effect of compost extract of mycelia growth, sporulation and spore germination of the three pathogenic fungi (*F.solani*, *F.acuminatum* and *Alternaria* sp*)*.in addition, the test manifested the suppressing of soil born and leaf on tomato plants by compost and their extract.

The biological control using compost has become a reliable and simple method for improving the quality and quantity of our yield. Equality important is the attainability of healthy and 100% organic product. Hence, it is a technique for the recovery of organic waste. It is interesting to note that our compost E2 can be used as soil fertilizer in agriculture as it can provide protection against fungal diseases. The present study had further confirmed the ability of compost to improve both; soil structure and nutrient availability. The inclusion of the biological alternative helps rendering crop production in better conditions.

In this article we addressed the current progress and challenges in Physico-chemical and biological characterization of the compost E2 and their potential for suppressing plant diseases. Nevertheless, there are still critical challenges regarding the enhancement of composting use and at a larger scale composting process. As a final remark, it is also vital to mention that the discovery of faster methods sustaining this process is highly recommended.

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Contribution of Authors:

Fatima Merah	:	Conduct research and manuscript write up.
Fatiha Lazreg	:	Help in conducting research experiments and manuscript up.
Lakhdar Belabid	:	Critically reviewed manuscript and provide technical assistance.
Jose Sanchez	:	Physical and chemical analysis of the compost.
Edwardo Gallego	:	Physical and chemical analysis of the compost.