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ORIGINAL PAPER

Efficiency of some Organic Matter on Suppression of Soil-Borne Diseases of Tomato Plants under Organic Agriculture System

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ABSTRACT

The present work was carried out during 2019/2020 and 2020/2021 successive growing seasons at the private organic farm, Bani Salama village, Mansha'at Al Qanater Al Khayriyah County, Giza Governorate, Egypt, to investigate the efficacy of different organic matters, *i.e.*, compost, plant residue, cow manure, vermicompost and humic acid on management of tomato root-rot disease incidence to increase the quality and quantity of tomato fruits. *Fusarium oxysporum*, *F. solani*, *Pythium* sp., *Rhizoctonia solani* and *Sclerotium rolfsii* were isolated from rotted samples of tomato roots. Pathogenicity test proved that these fungi are the main causal pathogens of tomato root-rot diseases. All tested organic matters showed a significant decrease in the linear growth of the isolated pathogenic fungi *in vitro*. Adding the different organic matters, *i.e.*, plant residue, cow manure and compost "plant residue + cow manure" at the rate of 1.2 kg/m^2 to the soil before transplanting Super Strain B hybrid tomato cv., as well as dipping tomato seedlings in diluted (1:50), as recommended dose of vermicompost or humic acid separately significantly reduced disease incidence *in vivo*. Also, assessment the highest increase in the survived plants in comparison with control treatment during both growing seasons. Compost, as rich organic fertilizer at the rate of 1.2 kg/m^2 caused the highest decrease in disease incidence and recorded also, the highest increase in vegetative growth "plant height, No. of brunches/plant and No. of leaves/brunch"; yield parameters; fruit quality "total soluble solid (TSS), vitamin C, protein and total carbohydrate"; chemical components of flavonoid, total phenol and the enzyme activities of peroxidase (PO), polyphenol oxidase (PPO), chitinase and β-1,3 glucanase during both growing seasons. On the contrary, the plant residue showed the least effect treatment. No clear significant differences were noticed between the other treatments in comparison with control treatment.

Key words: Tomato, *Lycopersicon esculentum* Organic manure, Humic acid, Vermicompost , Root-rot, Organic agricultures.

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INTRODUCTION

Tomato (*Lycopersicon esculentum*, Mill.) is one of the most important vegetable crops in the world as well as in Egypt. It is widely cultivated because it is rich in potassium, antioxidants, ascorbic acid, vitamin-C, lycopene and tocopherol to nourish human health (Capobianco-Uriarte *et al*., 2021). In Egypt, tomato is the most significant vegetable crops grown for local consumption, export purposes and ranked as the first vegetable cash crop with total planting area 185211 fed., which yielded about 3268740 ton of fruits (Ministry of Agriculture and Land Reclamation, February 2021). This area represented about 31.5 % of the total vegetable cultivated area in Egypt. Globally, Egypt is ranked in the fifth position in growing tomato crop (Anonymous, 2017).

Egyptian climate is favorable for tomato production as well as the incidence of several diseases most of the year. Common tomato cultivars are susceptible to soil-borne diseases, especially Rhizoctonia root rot caused by *R. solani* Kühn. It is one of several soil-borne diseases, responsible for root-rot and with higher disease severity reduces plant survival, resulting in a significant loss in crop yield (Ahmed, 2013).

In Egypt, tomato can be cultivated in different growing seasons, winter, summer and Nile; but the plants are subjected to the attack by many suppressive soil diseases (Ahmed *et al*., 2017). *Fusarium* spp., *Phytophthora* spp., *Alternaria solani*, *Rhizoctonia solani*, *Sclerotium rolfsii* and *Pythium* spp. are the most popular pathogens causing severe yield losses and quality of tomato all over the world and disease control is difficult (Hamza *et al*., 2016; Sharath Chandran *et al*., 2021 and Mergawy *et al*., 2022).

Many investigators trust in the positive efficacy of organic manure on tomato vegetative growth parameters, productivity, and chemical components. They stated that application of organic manure, compost, plant, and cow residues for tomato plants reduced Rhizoctonia root-rot disease and increased plant growth, yield parameters and N, P and K contents of tomato (Sullivan, 2004; Agyeman *et al.* 2014 and Ilupeju *et al.* 2015). Compost suppresses a wide variety of soil-borne pathogens, because it acts as a food source for biocontrol agents that produce antibiotics responsible for controlling and parasitize soil-borne pathogens. Moreover, the highest increase was recorded in chemical components such as total phenols, flavonoids, peroxidase (PO), polyphenoloxidase (PPO), chitinase, beta-1 and 3-glucanase, which have a role in effective control to soil-borne fungi of treated tomato roots (Ahmed *et al.,* 2017).

Martina and Brathwaite (2012) reported that, the physical and chemical properties of compost as biological control factors differ in their effect according to the different sources of compost and its components, which causes a difference in disease inhibition. Compost tea produced from compost has proven to be effective in inhibiting root-rot (*Pythium ultimum*, *Rhizoctonia solani* and *Phytophthora* spp.) and wilting (*Fusarium oxysporum* and *Verticillium dahliae*), in addition to increasing crop parameters (Ahmed, 2013).

Many researchers reported that potassium humate, vermicompost and alga (*Sparulina platensis*) as safe to the environment, human and animal health decreased the disease occurrence and severity of tomato root-rot disease and increased crop parameters and chlorophyll content (Abdel-Monaim *et al.,* 2012; Morales-Corts *et al.*, 2018 and Mohammed *et al*., 2021).

Fertilization of tomato plants with cattle, chicken manure or compost at rate of (120 kg N/fed.) gave highest values of crop parameters, plant chemical composition (Kumar *et al.*, 2013; Mesallam *et al*., 2017 and Ahmed, *et al*., 2018).

Vermicompost and humic acid are considered as a preventive measure to reduce disease incidence of vegetables root-rot (Chaudhary *et al*., 2004; Goswami *et al*., 2017 and Ali *et al*., 2019) and also contribute to increases the aeration capacity of soil which improving and increasing the quality, quantity, dry matter, vitamin C and sugars of vegetable crops (Barthod *et al*., 2018). Vermicomposting application as an environmentally friendly method helps to provide biocontrol agents that contribute to a biological control of *Fusarium oxysporum* f. sp. *lycopersici* the causal of Fusarium wilt of tomatoes compared with the control treatment (Zhao *et al*., 2019; Soylu, 2020 and Wang *et al.*, 2021).

The efficacy of compost fertilizers as a result of the activities of hydrolytic enzymes, which gives good indicators of the quantitative changes that occur in specific organic polymer concentrations during the composting process (Usmani *et al.*, 2018 and Qiao *et al.* 2019).

The primary goal of conducting this investigation is to evaluate the application of different safe organic matters as natural products alternative to chemical pesticides to control tomato root- rot disease incidence *in vivo* and to increase the quality and quantity of tomato fruits under organic farming systems to achieve environmental sustainability for soil, agriculture and food safety.

MATERIALS AND METHODS

1. Plant materials used during the investigation:

1.1. Tomato cultivar:

Seedlings of tomato (*Lycopersicon esculentum* Mill.) cultivar Super Strain B hybrid used in this investigation were kindly provided by the Vegetable Research Dep., Horticulture Research Institute, Agricultural Research Center, Dokki, Giza, Egypt.

1.2. Humic acid:

Humic acid was obtained from the Central Lab. of Organic Agriculture (CLOA), Agricultural Research Center, Giza, Egypt. which used as seedling dipping at the rate of 1 lit/50 lit water/fed.

1.3. Compost:

The extensive ripening compost was applied in this farm during the preparation of soil and before transplanting on the 2019/20 and 2020/21 growing seasons, respectively. Compost was obtained from the same farm, consisting of "extensive cow manure + plant residue from vegetable residues" and was applied at the rate of 1.2 Kg/m^2 / Fed. Composting operation taken (2.5 - 3 months) to enhance soil with organic matter and enrich the fertility. This amount provides the following nutrients according to the soil analysis (Table, 1) at Soil, Water and Environmental Research Institute, Agricultural Research Center, Giza, Egypt. Data in Table (1) show the high concentrations of macro elements which improve the quality and quantity of the target crop.

Table (1): Main parameters characteristics of mature compost.

Organic matter	Bulk weight (kg/m3)	Dry Matter (g/L)	% Humidity	pH (10:1)	EC (10:1) dS/m	Soluble N (mg/kg)		C/N	Total N (%)	Organic Matter (%)	Organic Carbon (%)	Total P (%)	Total K (%)
						NH_4+	NO_3-						
Compost	1010	90	30	6.50	2.39	42.5	27	1:11	1.50	83.28	16.50	1.20	0.8
Cow manure	750	35.36	54.74	7.50	1.25	68.9	20	1.16	0.86	81.00	14.43	0.63	0.75
Plant residue	650	80.10	12.50	6.50	3.50	52.5	18	1.12	1.45	82. 50	17.56	0.75	0.55

1.4. Vermicompost:

It was obtained from the Central Lab. of Organic Agriculture (CLOA); ARC; Egypt and used as seedling treatment with the rate of 1 L/50 L water/fed. Vermicomposting was prepared according to the method of (Znaïdi, 2002 and Morales-Corts *et al*., 2018). This amount provides the nutrients (Table, 2) according to the analysis carried out at Soil, Water and Environmental Research Institute, Agricultural Research Center, Giza, Egypt.

Data in Table (2) show the high concentrations of macro and micro elements which improve the quality and quantity of the target crop.

Table (2): Main parameters characteristics of vermicomposting.

pH (10:1)	EC (10:1) dS/m	C (%)	N (%)	C/N (%)	P (%)	K (%)	Fe (ppm)	Mn (ppm)	Zn (ppm)	Cu (ppm)
7.50	1.18	15.00	1.40	1:11	1.50	1.20	480	250	150	25.50

1.5. Soil analysis:

A representative sample of a mixture of clay and sandy soils (1:1 w/w) was collected from Bani Salama Village, Mansha'at Al Qanater Al Khayriyah County, Giza Governorate, Egypt. The collected soil for pot experiment was air dried, crushed and prepared to physical and chemical properties determinations according to the methods described by Piper (1966). The physical and chemical analysis of soil used in testing antagonistic show the activities of efficient different organic matter against root rot fungi *in vivo* are given in Table (3).

Table (3): Some Physio-Chemical Properties of field soil.

Soil Compositions					
Physical Properties		Chemical Compositions		Exchangeable bases (mol (+) kg)	
Clay %	07.66	pH (Kcl)	07.89	Zn (ppm)	1.82
Silt %	19.25	Total Carbon (g/kg)	00.22	Mn (ppm)	3.20
Sand %	72.59	Total Nitrogen (g/kg)	17.80	K (ppm)	160.45
EC (dS. m^{-1})	01.65	P (ppm)	65.85	Cu (ppm)	1.01
ECE (cmolc-Kg^{-1})	13.90	$CaCO_3$ %	05.00	CEC	5.80
Textural class	Sandy loamy	----	----	Fe (ppm)	14.98

2. Isolation, purification and identification of fungi associated with rotted roots of tomato

Samples of root-rotted tomato plants were collected from private organic farm, Bani Salama Village, Mansha'at Al Qanater Al Khayriyah County, Giza Gov., Egypt. Roots that were infected rinsed repeatedly in tap water, dried by air drying, surface sterilized by dipping in a solution of 3% chlorine for three minutes, washed repeatedly in sterile distilled water, and finally dried between two sheets of sterile filter paper. Surface sterile roots were cut into small pieces with a sterile scalpel and aseptically transferred to prepared Potato Dextrose agar (PDA) plates; each contains 10 ml of PDA medium (Sinclair and Dhingra, 2019). The plates were incubated at 25 ± 2 °C and checked periodically. The developed mycelium growth (s) were transferred to plates or other slopes containing PDA medium using the hyphal tip and/or single spore technique (Brown, 1924 and Hawker, 1960) and incubated at 28 ± 1 °C for seven days. The obtained pure cultures were stored at 5 °C for further use. The isolated fungi were identified in the Central Laboratory of Organic Agriculture, Agricultural Research Center, Egypt, according to its cultural, morphological and microscopic characteristics as described by Barnett and Hunter (1987). Identification was confirmed through the Dept. of Mycology Research and Plant Diseases Survey, Plant Pathology Research Institute, Agricultural Research Center, Egypt.

3. Pathogenicity tests:

Pathogenicity tests were carried out in potted soils under greenhouse conditions at the Central Laboratory of Organic Agriculture, Agricultural Research Center, Egypt. Plastic pots 20 cm, each containing 2.7 kg of light clay soil infested by the tested fungi each alone were prepared. Seedlings of Super Strain B hybrid tomato cv. obtained from Horticulture Res. Inst., (A.R.C), were used in this experiment.

3.1. Inoculum preparation

Preparing *Sclerotium rolfsii* inoculum by inoculated slant glass bottles (500 mL), each containing 100 mL of solid Gliotoxin Fermentation Agar (GFA) medium, each with one agar disc from the periphery of a 5-days old culture and incubated for 15 days at 30 ± 1 °C. Then, *S. rolfsii* - sclerotia was harvested using a smooth brush and added to the potted soil at the rate of 50 sclerotia/kg. soil (Ahmed, 2005 and 2013).

For preparing inoculum of each of *Fusarium oxysporum*, *F. solani*, *Pythium* sp. and *Rhizoctonia solani*, the corn sand meal medium supplemented with 0.2% peptone solution (Ahmed, 2005 and 2013) was used. The medium was distributed in glass bottles (500 ml), each contained 200 g. and autoclaved as usual. Autoclaved bottles were inoculated each, with 5 mm agar disc obtained from the periphery of the tested culture and incubated for 15 days at 25±2°C. Then the inoculated medium was added to the potted soil at the rate of 80g/kg soil and mixed thoroughly. In all cases, the soil was infested 10 days prior to transplanting. Tomato transplants from the Super Strain B hybrid cv. were planted in potted soil at a rate of two transplants per pot, infested or not (control), and each replicate had twenty plants in ten pots. For each treatment, three replicates were employed. The planted pots were kept in an open greenhouse as is customary. Periodically, tomato plants were inspected every week for seven weeks. To assess the virulence of each test pathogen, percentages of disease incidence were reported. Koch's postulates were applied as the tested fungus were re-isolated from the afflicted plants. Data were recorded as percentage of root rot disease incidence and survived plants in each treatment.

3.2. Disease assessment:

Ahmed (2013) used the following formula to calculate the percentages of root-rot disease incidence and survived plants in each treatment every week for seven weeks after transplanting.

$$\textbf{\% Disease incidence (DI)} = \frac{\textbf{Number of infected plants}}{\textbf{Total number of transplants}} \times 100$$

$$\textbf{\% Survived plants} = \frac{\textbf{Number of survived plants}}{\textbf{Total number of transplants}} \times 100$$

4. *In vitro* antagonistic potentiality of the tested different organic matter against the root rot pathogens:

The anti-activity of the tested organic matter treatments accomplished on autoclaved GFA plates (9 cm Ø). The different organic matters, humate, cow manure, plant residue, compost or vermicompost were prepared according to the method of Znaïdi, 2002, by placing each fertilizer separately in a 10-liter plastic container contain (1 kg / 5 liters of distilled water) and incubated for 7 days at 20-25°C, then filtered through double layers of cheesecloth, sterilized by filtration through centered glass filter (G5) (Ahmed, 2013). Each sterilized organic matter was added individually at the rate of 10 ml to conical flasks 125 ml containing 90 ml sterilized GFA before solidification to obtain concentrations of 10%. Separate GFA flasks free of organic matter were used as control treatment. The supplemented media were poured into Petri dishes (9 cm) in triplicates. After solidification, a disc (5 mmØ) of the tested pathogenic fungi obtained from the periphery of any tested pathogenic fungus (5-days old) grown on the same medium was placed in the center of each plate. The inoculated plates with pathogenic fungi agar disc only in the center of the plate served as un-treated control. All plates were incubated at 28±1°C. The experiment was terminated when mycelial growth of pathogenic fungi covers the medium surface in any plates of any treatment.

All plates were examined and the percentage of reduction in mycelial growth of the pathogenic fungi was determined using a formula:

$$\textbf{\% Reduction in linear growth} = \frac{\textbf{G1-G2}}{\textbf{G1}} \times 100$$

Where:

G1: growth of the pathogenic fungus in control only

G2: growth of the pathogen against the tested organic matter.

5. Field experiments:

Field experiments were carried out at private organic farm, Bani Salama village, Mansha’at Al Qanater Al Khayriyah County, Giza Governorate during two successive seasons (2019/20 and 2020/21) to estimate the efficiency of different organic matter for controlling root-rot of tomato plants. Root-rot pathogens were naturally present in the selected field test location. Three replicated plots were used in a complete randomized block design for all of the trials, and the experimental plot's surface area was 112.5 m^{2}, comprised of 3 ridges (25m × 1.5m) with about 50 cm apart. Foam trays were used to sow seeds at the nursery on 1st September and transplants were placed there 45 days later when they had 3-4 true leaves on 15th October of both seasons (Mohammed *et al*., 2021). Each ridge was transplanted with 50 transplants of Super Strain B hybrid tomato cv. in naturally infested soil.

5.1. Treating of tomato plants with different organic matters at the certain dose under field conditions during the growing seasons of 2019/20 and 2020/21:

In these experiments, all composted types were added at the rate of 1.2 Kg on dry basis/1 m^2) to the naturally infested soil in the field and irrigated daily. After 15 days tomato transplants of cv. Super Strain B hybrid were transplanted. In all experiments Super Strain B hybrid tomato cv. was used and dipped in diluted (1:50) as recommended dose of vermicompost or humic acid separately which mixed with 5% Arabic gum and 5% potassium soap for 10 minutes to increase adhesive capacity and improve distribution of organic matter on the surface of treating transplant, just before transplanting. Plots without using any organic matter were used to serve as control treatment. Three plots were used as replicates for each treatment. Each one composed of 3 ridges prepared as mentioned before (Ahmed, 2013). Plots were irrigated periodically by drip system from the well source and received all other normal organic agricultural practices. The recorded temperature under field conditions was around 25 ± 5° C, while the relative humidity was 60±10 R.H.

5.2. Disease assessment and different crop parameters:

In all field experiments, samples of three plants were chosen at random from every plot at the end of the growing season and directly transferred to the laboratory. The following data were recorded, disease incidence of root-rot and percentage of the survived plants were recorded 90 days after transplanting, plant height, fresh and dry weights of the plant, number of fruits/plant, yield components and morphological characters. In addition, determination of the treatments efficacy by using the formula according to Ahmed (2013):

$$\textbf{\% Efficacy of each treatment} = \frac{\textbf{Treatment - Control}}{\textbf{Control}} \times 100$$

5.3. Chemical components determination:

All the following chemical assays for the tomato plants were carried out in Central Laboratory of Organic Agriculture, Agricultural Research Center, Giza, Egypt.

5.3.1. Yield quality:

Nine samples of the third harvest of red-ripening tomato fruits were taken from each experimental plot to determine fruit quality parameters *i.e.*, total soluble solids (TSS) using a Carlzeiss hand Refractometer, the crude protein content (estimated by multiplying the sum. Nitrogen by 6.25) and quantification of ascorbic acid (mg/100g FW) according to (A.O.A.C., 2005 and Offor *et al*., 2015).

5.3.2. Determination of total protein and carbohydrate:

Nine leaves were randomly collected from plants of each replicate (3 replicates for each treatment). They were taken from the fourth upper of tomato stem, washed with distilled water, dried with sterile filter papers, then dried at 70°C and wet digested for the determination of total protein (Bradford, 1976) and total carbohydrate were extracted and prepared for assay according to Crompton and Birt (1967).

5.3.3. Determination of total phenols:

The amount of total phenols in extracts was determined by Folin-Ciocateu method as modified by Singleton *et al.* (1999).

5.3.4. Determination of total flavonoids content:

The flavonoid content is estimated in milligrams of rutin equivalents per gram of the digested sample (mg RE/g) as described by (Rice-Evans *et al*., 1996) method.

5.3.5. Enzymes determination:

Plant sample preparations:

Tomato leaf samples were weighed from 0.1-0.5 g and then stored at 20 °C until processed as described by Ni *et al*. (2001).

a. Determination of peroxidase (PO):

The activity of the peroxidase enzyme was estimated accordance to the instructions provided by Hammerschmidt *et al*., (1982).

b. Determination of polyphenol oxidase (PPO):

The activity of polyphenol oxidase was estimated according to Matta and Dimond (1963).

c. Determination of chitinase:

Chitinase enzyme activity was assesed by procedure of (Boller *et al*., 1988). Chitinase activity was measured as mM N-acetylglucose amine equivalent released/g fresh weight tissue/60 minutes.

d. Determination of β-1,3-glucanase:

β-1, 3-glucanase enzyme activity was determined as described by Sun *et al*. (2006) and estimated to be expressed as glucose equivalent mM/g fresh weight tissue/60 minutes.

6. Statistical analysis:

All the collected data were statistically analyzed and contrasted using the least significant difference (L.S.D.) mentioned by Snedecor and Cochran (1989).

RESULTS AND DISCUSSION

1. Isolation, purification and identification of fungi associated with rotted roots of tomato:

The isolated fungi of rotted roots of tomato plants collected from private farm, Bani Salama village, Mansha'at Al Qanater Al Khayriyah County, Giza Governorate, Egypt, were purified and identified as *Fusarium oxysporum*, *F. solani*, *Pythium* sp., *Rhizoctonia solani* and *Sclerotium rolfsii*.

Table (4): Occurrence and frequency (%) of fungi isolated from the rotten roots of tomato plants collected from Giza Governorate during 2019 growing season.

Isolated fungi	Occurrence	% Frequency
Fusarium oxysporum (Schlecht)	3	11.1
F. solani (Marti) Sacc.	3	11.1
Pythium sp. (Pringsheim)	2	7.40
Rhizoctonia solani (Kuhn)	10	37.1
Sclerotium rolfsii (Sacc.)	9	33.3
Total of isolates	27	----

The presented data in Table (4) showed that *R. solani* and *S. rolfsii* were of the highest frequency among the fungi isolated from rotted tomato samples collected from Giza Governorates. Identification was determined according to their cultural, morphological and microscopic characteristics according to the method of Barnett and Hunter (1987).

2. Pathogenicity tests:

The pathological ability of the isolated fungi (Table, 4) to cause root-rot disease *in vivo* under greenhouse conditions was evaluated. The presented data in Table (5) reveal that, all isolated fungi have the ability to cause root-rot disease of tomato plants. *R. solani* showed more aggressiveness than the rest of the other fungi as it recorded the highest percentage of root-rot incidence (95.30%) and showed the lowest percentage (04.70%) of survived plants, followed by *S. rolfsii*, being 83.67 and 16.33%, respectively. The fungus *Pythium* sp. showed the lowest percentage of root-rot diseases (55.50%) and recorded the highest percentage (44.50%) of survived plants (7-weeks post transplanting). These results are consistent with those reported by Ahmed (2013); Ahmed *et al.* (2017) and Sharat Chandran *et al.* (2021) who stated that secretions and interaction of oxalic acid and polygalacturonase caused by pathogens in soil are responsible for root destruction.

Table (5): Pathogenicity test of the isolated fungi expressing disease incidence on tomato plants (Super Strain B hybrid), 7-weeks post transplanting, under greenhouse conditions.

The tested fungi	Root-rot incidence (%)	Survived plants (%)
F. oxysporum (Schlecht)	75.67	24.33
F. solani (Marti) Sacc.	73.34	26.66
Pythium sp. (Pringsheim)	55.50	44.50
R. solani (Kuhn)	95.30	04.70
S. rolfsii (Sacc.)	83.67	16.33
Control "Untreated"	00.00	100.00
L.S.D. at 5%	0.95	1.14

3. *In vitro* antagonistic potentiality of the tested different organic matters against the root-rot pathogens:

The results obtained in Tables (4 and 5) showed that the isolates of *R. solani*, *S. rolfsii*, *F. oxysporum* and *F. solani* were the four most aggressive isolates in their pathogenicity to cause tomato root-rot disease. This experiment carried out to assess the impact of different organic matters against the mycelial growth of each the pathogenic isolates that cause root-rot. Presented data in Table (6) reveal that the organic matters differently varied in their effect against the tested fungi. All tested organic matters showed a significant decrease in the linear growth of the isolated fungi. The results showed that compost was the most efficient organic matter in causing a significant decrease to the mycelial growth of all tested pathogens by 79.69%, on the average, followed by vermicompost, being 77.44% on the average then humic acid, being 76.26% on the average. On the contrary, plant residues had the lowest effect, being 66.01% on the average. The average reduction in radial growth of by *F. solani* recorded the most sensitive to various organic matters in the mycelium growth, being 80.88% on the average, followed by *R. solani*, being 77.50% on the average, then F. *oxysporum*, being71.63% on the average, and *S. rolfsii*, being 66.15% on the average.

These results are in harmony with the obtained results of Morales-Corts *et al.* (2018) and Wang *et al*. (2021) who stated that, the full decomposed mature of organic matters had the ability to biological control by excreting many glucoses and sugars during early decomposition. These soluble nutrients in turn support the growth of bio microbes to control pathogens.

Table (6): Effect of different organic matters on percentage (%) of reduction in linear growth of the pathogenic fungi.

Organic matter	% Reduction in linear growth of the tested fungi				
	F. solani	*F. oxysporum*	*R. solani*	*S. rolfsii*	Mean
Plant residue	73.82	61.67	68.83	59.71	66.01
Cow manure	76.33	69.95	74.66	62.33	70.82
Compost	88.20	77.33	82.50	70.71	79.69
Humic acid	82.50	73.55	80.33	68.67	76.26
Vermicompost	83.55	75.67	81.20	69.33	77.44
Control	00.00	00.00	00.00	00.00	00.00
Mean	80.88	71.63	77.50	66.15	73.19
L.S.D. at 1% for:					
Pathogenic fungi (P) =			0.84		
Organic matter (O) =			1.11		
O × P =			1.22		

4. Effect of different organic matters on the incidence of root-rot under field conditions during 2019/20 and 2020/21 growing seasons:

4.1. Disease control:

Data in Table (7) reveal that all the added organic matters, *i.e.*, plant residue, cow manure and compost "plant residue + cow manure" to the soil before transplanting tomato at the rate of 1.2 Kg/m^2 and transplants treatment with diluted of 1:50 as a recommended dose of vermicompost or humic acid separately significantly reduced disease incidence and also, increased the percentage of the survived plants in comparison with control treatment during 2019/20 and 2020/21 growing seasons. Compost was the most effective one, being 17.01 and 32.21% followed by vermicompost (16.28 and 31.20%) in decreasing the disease incidence during 2019/20 and 2020/21growing seasons, respectively compared with control treatment. On the other hand, plant residue was the least effective one, being 12.21 and 18.89 %, respectively.

Table (7): Effect of adding different organic matters to tomato plants on disease incidence under field conditions during 2019/20 and 2020/21 growing seasons.

Treatments	2019/20 growing season			2020/21 growing season		
	Root-rot incidence %	Survived plants %	Efficacy %	Root-rot incidence %	Survived plants %	Efficacy %
Plant residue	22.80	77.20	12.21	29.50	70.50	18.89
Cow manure	21.70	78.30	13.81	26.30	73.70	24.28
Compost	19.50	80.50	17.01	21.60	78.40	32.21
Humic acid	20.30	79.70	15.84	22.80	77.20	30.19
Vermicompost	20.00	80.00	16.28	22.20	77.80	31.20
Control	31.20	68.80	-------	40.70	59.30	----
L.S.D. at 5%	1.03	0.75		1.04	0.74	

The use of organic matter to tomato plants as soil amendments (Tables, 1 and 2) resulted in a better soil quality and greater plant disease suppressiveness (Sullivan (2004); Martina and Brathwaite (2012); Ahmed (2013) and Sharath Chandran *et al*., 2021); however, in this study it depended on the type of organic fertilizer. These data are in agreement with those obtained by Sullivan (2004); Zmora-Nahum *et al.* (2008) and Deeksha *et al.* (2009) who stated that different organic matters improve soil properties due to their ammonium-fixing, nitrifying, and cellulose-destroying bacteria content, enrich the soil's macro- and microelement composition**.**

On the other hand, compost as rich fertilizer contains more antagonistic microorganisms than the other two organic matters either regarding nutrient content or microbial population. Also, the effect resulting from organic matter contains a large amount of bio-microorganisms in the soil that contribute to an increase in the share of these organisms, which in turn participate in the secretion of metabolites that analysis protein which reduces the percentage of dangerous pathogenic bacteria (Goswami *et al*., 2017) and Ali *et al*., 2019).

4.2. Growth parameters:

Vegetative growth in terms of plant height, no. of brunches/plant and No. of leaves/brunch showed clear positive trends in increasing due to using all tomato seedling treatments as shown in Table (8). The best results were recorded in the treatment of compost consisted of plant residue and cow manure, being (66 cm, 13 and 13) and (68 cm, 13 and 13) in morphological characteristics, *i.e.*, plant height, branch no. and no, of leaves/branch during 2019/20 and 2020/21 growing seasons, respectively followed by vermicompost treatment. On the contrary, plant residue showed the lowest effect in comparison with untreated plants during the two successive growing seasons.

Table (8): Effect of adding different organic matters to the soil of tomato plants on vegetative parameters under field conditions during 2019/20 and 2020/21 growing seasons.

Treatments	2019/20 growing season			2020/21 growing season		
	Plant height (cm)	Branch No.	No. of leaves/ branch	Plant height (cm)	Branch No.	No. of leaves/ branch
Plant residue	55.80	9	9	56.00	9	9
Cow manure	60.50	10	10	61.00	10	10
Compost	66.00	13	13	68.00	13	13
Humic acid	64.00	11	11	65.00	11	11
Vermicompost	65.50	12	12	66.00	12	12
Control	45.00	5	4	45.50	5	4
L.S.D. at 5%	2.35	0.34	0.22	2.46	0.33	0.22

These results agree with those obtained by Sullivan (2004) who reported that soil-borne diseases result from a reduction of biodiversity of soil organisms. Obtained results are true during both seasons of study and in harmony with those reported by Mesallam *et al*. (2017) who stated that, increasing in all measured growth parameters may be due to the main role of organic matter as biofertilizers in fixation of atmospheric nitrogen and secreting organic acids which lower the pH , conversion mineral and organic nutrients to available form easily to be absorbed by plants which in turn affected positively plant growth (Goswami *et al*., 2017; Ali *et al*., 2019 and Mohammed *et al*., 2021).

4.3. Effect on plant fresh and dry weight:

Data presented in Tables (9-a and 9-b) reveal that treatment with compost resulted in significant increase in the percentage of fresh and dry weight of shoots (55.32 and 144.53%) and roots (66.16 and 117.95%), respectively during 2019/20 growing season and gave the highest increase in fresh and dry weight of shoots (58.12 and 166.85%) and roots (77.67 and 205.17%), respectively during 2020/21 growing season compared with untreated plants.

On the contrary, plant residue treatment was the lowest effective one during the two growing seasons. In general, all different treatments led to conspicuous improvement in the aforementioned crop parameters during the two growing seasons 2019/20 and 2020/21 compared with control treatment. Obtained results are in agreement with those reported by Sullivan (2004) and Ahmed, 2013. In this respect, many investigators reported that under sandy soil conditions microbein fertilizer at 200g/acre gave the highest number of both leaves and branches/plant, dry weight of branches, leaves and total dry weight/plant. These results are in harmony with (Kumar *et al.*, 2013; Ahmed, *et al*., 2018 and Morales-Corts *et al.*, 2018) who explained the increase of fresh and dry weights of tomato plants which is a natural material that can improve soil physical and chemical properties and nutrient dynamics.

Table (9.a): Effect of adding different organic matters to the soil of tomato on fresh, dry weights of shoots and roots in "g"/plant under field conditions during 2019/20 growing season.

Treatments	Fresh weight				Dry weight			
	Shoots	Change * %	Roots	Change * %	Shoots	Change * %	Roots	Change * %
Plant residue	167.50	28.16	41.11	29.15	16.70	21.90	6.40	64.10
Cow manure	190..30	45.60	48.83	45.60	31.50	45.60	6.50	45.60
Compost	203.00	55.32	52.89	66.16	33.50	144.53	8.50	117.95
Humic acid	201.30	54.02	50.83	59.69	31.30	128.47	7.00	79.49
Vermicompost	202.50	54.93	51.33	61.26	32.00	133.58	8.00	105.13
Control	130.70	------	31.83	------	13.70	------	3.90	------
L.S.D. at 5%	2.12		0.48		0.26		0.11	

***Change % = [(Treatment – Control) / Control] × 100**

Table (9.b): Effect of adding different organic matters to the soil of tomato on fresh, dry weights of shoots and roots in "g"/plant under field conditions during 2020/21 growing season.

Different treatments	Fresh weight				Dry weight			
	Shoots	Change * %	Roots	Change * %	Shoots	Change * %	Roots	Change * %
Plant residue	167.85	30.42	41.20	38.12	16.90	33.07	6.50	124.14
Cow manure	190.50	45.60	49.00	45.60	31.75	45.60	6.75	45.60
Compost	203.50	58.12	53.00	77.67	33.89	166.85	8.85	205.17
Humic acid	201.50	56.57	51.00	70.97	31.50	148.03	7.50	158.62
Vermicompost	202.89	57.65	52.00	74.32	32.60	156.69	8.00	175.86
Control	128.70	------	29.83	------	12.70	------	2.90	------
L.S.D. at 5%	2.14		0.49		0.27		0.12	

***Change % = [(Treatment – Control) / Control] × 100**

4.4. Yield components:

Resulted data in Table (10) reveal that using any of organic matters to tomato seedlings led to significant increase in the estimated yield parameters in 2020/21 growing season than in 2019/20 growing season. Compost which consists of cow manure and plant residue showed the best results and caused significant increase in number of fruit/plant, average fruit weight and fruit yield/plant, respectively, being (42.5, 96.5g and 4101.25g) in 2019/20 growing season and (43.5, 95.50 g and 4154.25 g) in 2020/21 growing season, respectively compared with untreated plants. On the contrary, plant residue was the least effective one during the two growing seasons.

In most cases, there were significant differences in the estimated values in both growing seasons due to using cow manure. In this connection, Ahmed, 2013 and Ahmed *et al.*, 2017 who came to the same conclusion. Some investigators dealt with the effect of organic manure on vegetative growth, yield and chemical constituents. They stated that application of organic manure increased dry weight/plant; N, P and K contents, number of fruits/plant, average fruit weight and yield/plant and per feddan (Agyeman *et al.* 2014; Ilupeju *et al.* 2015 and Mesallam *et al.*, 2017) on tomato plants in comparison with control treatment.

Table (10): Effect of adding different organic matters to the soil of tomato on yield components under field conditions during 2019/20 and 2020/21 growing seasons.

Treatments	2019/20 growing season			2020/21 growing season		
	No. of fruit/ plant	Average fruit weight/ (g/fruit)	Fruit yield (g/plant)	No. of fruit/ plant	Average fruit weight/ (g/fruit)	Fruit yield (g/plant)
Plant residue	39.3	85.5	3360.15	39.8	84.5	3363.10
Cow manure	39.5	90.5	3574.75	40.5	90.3	3657.15
Compost	42.5	96.5	4101.25	43.5	95.5	4154.25
Humic acid	41.0	95.0	3895.00	42.0	94.0	3948.00
Vermicompost	41.5	95.5	3963.25	42.5	94.5	4016.25
Control	12.9	45.8	590.82	13.2	45.8	604.56
L.S.D. at 5%	1.15	2.44	12.11	1.16	2.45	9.44

4.5. Flavonoids and total phenols as chemical components determination:

Data in Table (11) indicate that all tested organic matter treatments at the rate of 1.2 Kg/ m^2 to the soil of tomato plants affected positively the activities of flavonoids and total phenols in leaves of tomato plants in comparison with control treatment during the two successive seasons (2019/20 and 2020/21). In this respect, the highest effective treatment on flavonoids and total phenols was compost treatment, where it recorded 45.00, 177.00 during 2019/20 growing season and 44.65, 178.20 % during 2020/21, respectively, followed by vermicompost. On the other hand, plant residue showed the lowest effect in comparison with the other treatments. These results are in harmony with those reported by Ahmed (2013) who came to the same conclusion when tomato plants were dealt with the effect of organic manure on vegetative growth, yield and chemical constituents (Tables, 1 and 2) it can improve soil physical and chemical properties and nutrient dynamics (Kumar *et al.*, 2013; Ahmed *et al.*, 2017 and Ahmed *et al*., 2018).

Table (11): Effect of adding different organic matters to the soil of tomato on the activity of flavonoids and total phenols under field conditions during 2019/20 and 2020/21 growing seasons.

Treatments	2019/20 growing season		2020/21 growing season	
	Flavonoids	Total phenols	Flavonoids	Total phenols
Plant residue	35.00	160.00	35.53	160.30
Cow manure	42.00	170.50	42.55	172.00
Compost	45.00	177.00	44.65	178.20
Humic acid	43.50	175.00	43.65	177.00
Vermicompost	44.50	175.50	44.00	177.50
Control	30.00	125.20	32.00	32.50
L.S.D. at 5%	1.33	2.22	1.44	2.20

4.6. Effect of applying different organic matters to the soil of tomato plants on the fruit quality under field conditions:

Data in Table (12) illustrate the role of different organic matters on the nutrition of tomato plants. Results revealed that there were changes occurred in fruit quality "total soluble solid (TSS), Vitamin C, protein and total carbohydrate due to these treatments in comparison with control treatment during the two seasons (2019/20 and 2020/21). Presented data in Table (12) indicate that extensive compost treatment was the highest effective one concerning total soluble solids (TSS), being 5.50 and 5.65, Vitamin C, being 42.83 and 42.93 mg/100g FW, protein being 2.85 and 2.89 g/100g FW and total carbohydrate, being 31.33 and 31.43 mg/100g FW during both seasons, respectively followed by vermicompost then humic acid.

On the opposite trend, plant residue showed the least effective treatment compared to control treatment. Finally, all organic matters improved the fruit quality and the results in the 2020/21 growing season were higher than in 2019/20 growing season. The obtained results are in harmony with those obtained by (Ahmed *et al.*, 2017; Barthod *et al*., 2018; Sharath Chandran *et al*., 2021 and Mohammed *et al*., 2021), who explained That instead of the increment in physical and chemical quality attributes may be due to the increase of macronutrient content of plant tissues which affect photosynthetic assimilation rate and in turn increased accumulation of total soluble solids in fruit and ascorbic acid, total acidity and carbohydrate, which was intermediate products during the photosynthetic assimilation process. It is also contributed to increasing the aeration capacity of the soil, which improves and increases the quality, quantity, dry matter, vitamin C and sugars of vegetable crops.

Table (12): Effect of adding different organic matters to the soil of tomato on fruit quality under field conditions during 2019/20 and 2020/21 growing seasons.

Treatments	2019/20 growing season				2020/21 growing season			
	TSS	Vitamin C (mg/100g FW)	Protein (g/100g FW)	Carbohydrate (mg/g FW)	TSS	Vitamin C (mg/100g FW)	Protein (g/100g FW)	Carbohydrate (mg/g FW)
Plant residue	4.00	38.00	1.65	22.70	4.25	38.50	1.70	22.75
Cow manure	5.10	39.50	2.08	27.47	5.15	39.55	2.09	27.50
Compost	5.50	42.83	2.85	31.33	5.65	42.93	2.89	31.43
Humic acid	5.30	40.60	2.65	29.11	5.35	40.65	2.68	29.22
Vermicompost	5.40	41.33	2.75	30.22	5.44	41.40	2.79	30.25
Control	3.20	19.60	0.95	13.85	3.24	19.70	0.96	13.97
L.S.D. at 5%	0.20	2.30	0.45	2.12	0.21	2.32	0.44	2.10

4.7. Effect of treating tomato plants with some organic matter treatments on the activity of enzymes under field conditions:

Data in Table (13) illustrate that all organic matter treatments, which were used to treat tomato transplants affected positively the enzyme activities of peroxidase (PO), polyphenol oxidase (PPO) chitinase and β-1,3 glucanase in leaves of tomato plants comparing with control treatment. In this respect, compost was the highest effective organic matter treatments in 2020/21 growing season and showed the highest records of PO, PPO, chitinase and β-1,3 glucanase enzymes, (Table, 13) being, 196.00, 13.50, 21.00 and 3.93 respectively. In 2019/20 growing season, it recorded 195.00, 13.20, 20.00 and 3.83, respectively followed by vermicompost, being 194.0, 12.89, 19.0 and 3.75 during 2019/20 growing season and 195.0, 13.0, 20.0 and 3.85 during 2020/21 growing season, respectively.

On other hand, plant residue treatment showed the least effect of enzymes activities in comparison with control treatment. In general, humic acid and cow manure treatments were moderately effective in this respect. These results agree with those reported by Ahmed, *et al.* (2017) who found the integration between compost and bioagents was the most effective treatment for reducing the incidence and severity of tomato root-rot. The same authors, also, recorded the highest increase of fresh, dry weight and yield of tomato. In addition, they recorded the highest increase in the total phenols, flavonoids contents, peroxidase (PO), polyphenol oxidase (PPO), chitinase and β-1, 3-glucanase activities in treated tomato plants in comparison with control treatment due to increasing micronutrients complexes formation and the mode of action of K in enhancing the photosynthetic activity and enzymes of carbohydrates transformation on membrane permeability of plants. Usmani *et al.* (2018) revealed that hydrolytic enzymes, due to their inductive nature, were good indicators of quantitative and qualitative changes happening in the content of individual organic polymers in the composting process. Qiao *et al.* (2019) stated that activities of cellulase, β-glucosidase and protease exhibited significant correlations with community of microorganisms within the thermophilic and mesophilic phases.

Table (13): Effect of adding different organic matters to the soil of tomato on the enzyme activity of peroxidase (PO), polyphenol oxidase (PPO), chitinase and β-1,3 glucanase enzymes in tomato plants grown under field conditions during 2019/20 and 2020/21 growing seasons.

Treatments	2019/20 growing season				2020/21 growing season			
	PO	PPO	Chitinase	β-1,3 glucanase	PO	PPO	Chitinase	β-1,3 glucanase
Plant residue	165.00	11.60	17.50	2.95	165.50	11.80	17.80	2.98
Cow manure	180.00	12.50	18.00	3.50	182.00	12.60	18.50	3.55
Compost	195.00	13.20	20.00	3.83	196.00	13.50	21.00	3.93
Humic acid	192.00	12.65	18.20	3.60	192.50	12.70	19.00	3.68
Vermicompost	194.00	12.89	19.00	3.75	195.00	13.00	20.00	3.85
Control	158.00	5.95	7.50	1.43	160.00	6.22	7.55	1.44
L.S.D. at 5%	2.33	0.44	0.46	0.11	2.44	0.45	0.47	0.12

CONCLUSION

Adding the different organic matters *i.e.*, plant residue, cow manure and compost "plant residue + cow manure" to the soil of organic farm before transplanting Super Strain B hybrid tomato at the rate of 1.2 Kg/m^2 or dipped tomato seedlings in diluted (1:50) as recommended dose of vermicompost or humic acid separately significantly reduced disease incidence and also, increased the percentage of the survived plants in comparison with control treatment during 2019/20 and 2020/21 growing seasons. Compost, as tomato rich organic fertilizer at the rate of 1.2 Kg $/m^2$ caused the highest decrease in disease incidence, also the highest increase in vegetative growth (plant height, No. of brunches/plant and No. of leaves/brunch); yield parameters; fruit quality "Total soluble solid (TSS), Vitamin C, protein and total carbohydrate", chemical components of flavonoid, total phenol and the enzyme activities of peroxidase (PO), polyphenoleoxidase (PPO) chitinase and β-1,3 glucanase during the two growing seasons. A significant differences were noticed between other treatments in respect to plant growth characteristics. The present work aim to evaluate the potential of different organic matter as natural products as potential alternatives to the application of synthetic fungicides which injury on the environment and human health because it highly toxic substances produced in agricultural led to, great disturbance in biological balance for controlling tomato root-rot and increasing the yield parameters of tomato plants *in vivo* under organic agriculture system and as plant promoters in crop production, for attaining environmental sustainability for farming and food safety.

CONFLICTS OF INTEREST

The author(s) declare no conflict of interest

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