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Research Article

Potential of *Pleurotus sajor-caju* compost for controlling *Meloidogyne incognita* and improve nutritional status of tomato plants

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Abstract

The potential of spent compost of oyster mushroom, *Pleurotus sajor-caju* cultivated on rice (MCR) or wheat straws (MCW) was evaluated against the root-knot nematode, *Meloidogyne incognita* on tomato plants under field conditions during two successive seasons (2016 and 2017). The field trial was carried out in a clay loam soil naturally infested with *M. incognita* at a private farm, Kafr El-Sheikh governorate, Egypt. Results revealed that all the tested treatments greatly suppressed final populations (P_f), numbers of galls and egg masses of *M. incognita* during both seasons as compared to the untreated treatment. The highest percentages of P_f reductions (81.1 - 87%) and (80.2 - 86.2%) were achieved with the chemical nematicide, Vydate® 10 G and treatments of (MCR and MCW) at application rate of 1200 g/m^2 in the 1st and 2nd seasons, respectively. Moreover, the fruit yield during both seasons was increased significantly with all the applied treatments, especially treatment of MCW at application rate of 1200 g/m^2. Additionally, chemical fruit properties were markedly improved with MCR and MCW treatments. Also, treatments of MCR and MCW achieved the highest percentages of nitrogen and phosphorus contents. Generally, the results indicated that spent compost obtained after cultivation of *P. sajor-caju* has a nematicidal potential against *M. incognita*, also improved nutritional status and increased tomato yield.

More Information

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Keywords: Agricultural residues; Biocontrol; Fruit quality; Organic amendments; Oyster mushroom; Root-knot nematode

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Introduction

Tomato (*Solanum lycopersicum* Mill.) is one of the main industrial and exportable vegetable crops in the world and in Egypt [1]. Carotenoids, particularly lycopene pigment present in tomato fruits, appears to be an active compound in the prevention of cancer, cardiovascular risk and slowing down cellular aging, owing to its high antioxidant and antiradical power [2-4].

Globally, plant parasitic nematodes cause high yield losses for about US$118 billion yearly [5]. The root-knot nematodes (*Meloidogyne* spp.) are the most widespread nematodes that cause more than 27% losses of tomato yield [6,7]. In Egypt, root-knot nematode attack tomato crops and causes seriously crop damage particularly in the infested sandy soil [8].

Management of *Meloidogyne* spp. is extremely difficult due to their wide range of the hosts, short periods of high reproductive rate and generation [9]. Several strategies, including resistance cultivars , organic soil amendments, and biological control have been developed as alternatives to chemicals in the management of plant parasitic nematodes [10-12]. The nematode management in ecofriendly sustainable agricultural systems includes using organic residues as low-input materials in agriculture system which is considered as an economical solution for the environmental problem resulting from the disposal of organic waste materials, as well as enhancing soil structure and increase water holding capacity [13-16]. Numerous succeed trials have been made to apply non chemical methods to manage root-knot nematode, *M. incognita* infecting tomato plants by adding uncomposted materials or mushroom compost prior to planting in nematode-infested soil [17-20].

The oyster mushrooms (*Pleurotus* spp.) are useful decomposers of various agricultural wastes [21]. Cultivation of oyster mushroom is a biotechnological process for lignocellulosic wastes recycling. This process has two targets; the production of protein-rich food and the reduction of the environmental pollutants. Agricultural residues such as rice and wheat straws are the major source of lignocellulosic materials, which is best substrate for solid state fermentation of *Pleurotus sajor-caju* [22,23]. Spent mushroom compost (MC) can be used as an effective tool to manage root-knot nematodes on tomato [24]. Results from previous experiments revealed the nematophagous ability of *Pleurotus* species [25,26].

Plants utilize nutrients from different sources such as the indigenous soil supply, fertilizers and organic residues applied to the soil [27]. Chemical fertilizer is an indispensable source of the nutrients, which are essential for improving overall plant growth, health, and quality. However, heavy use of chemical fertilizers can contribute to environmental contamination unless managed properly [28]. Sustainable agriculture based on integrated plant nutrition systems (IPNS) approach. The IPNS aims to use of chemical fertilizers and organic residues in an integrated manner [29]. Nutrients can reduce disease severity, affect the environment to deter pathogens and also induce resistance or tolerance in the host plant [30]. Nematodes are among the pathogens that can be affected by plant nutrition. Applying fertilizer can, partially, offset nematode-induced damage by stimulating plant development and decreasing the need for chemical control [31,32].

Therefore, objectives of the current research were (1) to evaluate the potential and feasibility of using spent compost of *P. sajor-caju* which cultivated on two kinds of locally agro-residual wastes (rice or wheat straws) as an organic approach to manage root-knot nematode, *M. incognita* through direct incorporation of spent compost into the soil before transplanting of tomato seedlings; (2) to determine the effect of *P. sajor-caju* compost, when applied at rates of 2.5 and 5 ton/feddan on enrichment nutritional status, yield and fruit quality of tomato plants during two successive seasons (2016 and 2017).

Materials and Methods

The field experiment was carried out during 2016 and 2017 summer seasons to evaluated the nematicidal potential of spent compost of oyster mushroom, *Pleurotus sajor-caju* (Fr.) Singer, which cultivated on rice (MCR) or wheat straws (MCW), for controlling the root-knot nematode, *Meloidogyne incognita* on tomato (*Solanum lycopersicum* Mill.) hybrid "Elisa" and their impact on yield and fruit quality comparing to the chemical nematicide, Vydate® (Oxamyl 10% G) at a private farm, Kafr El-Sheikh governorate, Egypt.

Physio-chemical properties of the experimental soil location

A composite surface soil samples at a depth of 0-30cm were taken from the experimental location before planting time for both seasons, air-dried, ground and passed through 2 mm sieve pores, then samples were sent for analysis and determination of physico-chemical properties in Department of Soil and Water Sciences, Faculty of Agriculture, Alexandria University. The physical and chemical properties of soil samples are shown in table 1.

Spent mushroom compost (MC) used in this experiment

The tested mushroom compost was collected after completion the harvested crop of oyster mushroom (*P. sajor-caju*), which cultivated on two kinds of locally agricultural wastes; rice (MCR) or wheat straws (MCW). The evaluated MCR (spent fungal mat + composted rice straw) and MCW (spent fungal mat + composted wheat straw) were obtained from the production unit of oyster mushroom at the Integrated Protection Laboratory, Plant Protection Research Station, Sabahiya, Alexandria governorate, Egypt. Samples of rice and wheat straws before and after *P. sajor-caju* growth were sent to the Department of Soil and Water Sciences, Faculty of Agriculture, Alexandria University for analysis and determination of macro and micro nutrient elements contents. The chemical analyses of rice and wheat straws before and after *P. sajor-caju* growth were shown in table 2.

Field experiment applications

The experimental field was divided into plots, each comprising rows of 5 m long and 50 cm apart and the distance between the plants were 40 cm. Research plots included six treatments assigned in a randomized complete block design (RCBD). Initial population (P_i) of *M. incognita* were estimated prior transplanting time by sieving and decanting methods [33] using 250 g subsamples of well mixed soil collected from each row.

The applied treatments during 2016 & 2017 summer

Table 1: Physio-chemical properties of the experimental soil location

Physical properties				Chemical properties											
Particle size distribution (%)				*pH	**EC (dSm^{-1})	Cation and anion concentration (meq L^{-1})							Available P (mg kg^{-1})	OM (%)	Total N (%)
Sand	Silt	Clay	Texture			Ca^{2+}	Mg^{2+}	K^+	Na^+	HCO_3^-	Cl^-	SO_4^{--}			
1st season															
23.4	37.6	39.0	Clay loam	7.81	2.03	4.83	5.67	0.58	8.92	3.89	6.25	9.86	8.94	2.25	0.19
2nd season															
25.1	36.4	38.5	Clay loam	7.83	2.15	5.00	5.94	0.63	9.87	4.30	7.29	9.85	9.78	2.97	0.20

*pH was determined in soil water suspension (1:2.5), ** EC was determined in saturated soil paste extract

Table 2: Chemical analysis of rice and wheat straws before and after oyster mushroom cultivation.

Sample	Element										C:N ratio
	N	P	K	C	Ca	Mg	Fe	Mn	Zn	Cu	
	%						ppm				
Rice straw	0.45	0.37	0.48	21.68	0.29	0.10	48.20	29.01	36.16	11.30	48.2:1
MCR	1.01	0.76	0.85	19.87	1.50	0.65	152.10	97.82	56.30	36.73	19.7:1
Wheat straw	0.40	0.32	0.57	22.10	0.40	0.17	62.12	25.00	30.75	12.42	55.3:1
MCW	0.87	0.70	1.09	17.86	1.65	0.74	161.80	92.54	51.23	39.10	20.5:1

MCR: Spent compost of *P. sajor-caju* grown on rice straw substrate, MCW: Spent compost of *P. sajor-caju* grown on wheat straw substrate.

seasons were as follows:

1. MCR applied at rate 600 g/m^2 (2.5 ton/feddan).
2. MCR applied at rate 1200 g/m^2 (5 ton/feddan).
3. MCW applied at rate 600 g/m^2 (2.5 ton/feddan).
4. MCW applied at rate 1200 g/m^2 (5 ton/feddan).
5. The nematicide, Vydate® (Oxamyl 10% G) applied at rate 5 g/m^2 (20 kg/feddan).
6. Non-treated plants.

Fresh mushroom compost (MCR or MCW) were directly incorporated and mixed into the upper 20-25 cm of soil surface at the application rates of 600 or 1200 g/m^2 and irrigated soon to the field capacity. Two weeks after treatments application, tomato seedlings of the hybrid Elisa (40 days old) were transplanted. Chemical fertilizers were added during the growth stages of tomato plants and the other agricultural practices were done according to the recommendation of the Egyptian Ministry of Agriculture.

Four months later, at harvest time, tomato plants randomly taken from each row, carefully uprooted and numbers of galls and egg-masses per root system of tomato plants were recorded. Average numbers, of five counts, of *M. incognita* juveniles (J_2) were taken to determine the final nematode population densities (P_f) in soil [33]. The reproduction factor (Rf) was also calculated [34]. Reduction % (R) of *M. incognita* population in soil was calculated at the end of the experiment using the formula of Mulla, et al. [35], as follows:

$$R\ (\text{reduction } \%) = 100 - [(C1/T1) \times (T2/C2) \times 100].$$

Where:

C1=pre-treatment population density in control;

C2=post-treatment population density in control;

T1=pre-treatment population density in treatment;

T2=post-treatment population density in treatment.

Vegetative growth parameters

At 75 days after transplanting of both seasons, random tomato plants from each row were taken to determine the following parameters; plant fresh and dry weights (including shoot and root), fresh weights of stem and leaves (g/plant) and leaf area (cm^2/plant) was measured after the first fruit harvest according to Yousri [36].

Fruit number and yield

During both seasons, tomato fruits were picked weekly through the harvesting period for yield parameters estimation; number of fruits/plant, unmarketable fruits (%) as a percent of the total fruit yield, average fruit weight (g) and fruit yield (g/plant).

Fruit quality parameters

Random samples of 30 fruits from each treatment were collected at the fourth picking of both experimental seasons to determine the total soluble solids content (TSS %), acidity (%), ascorbic acid (vitamin C mg/g), dry matter (%) and Ca (%). All these parameters were measured according to AOAC methods [37].

Leaf chemical composition

After 15 days from last addition of chemical fertilizer doses during both seasons, total chlorophyll was extracted using N, N-dimethyl formaldehyde and expressed as mg/g fresh weight according to Moran, et al. [38]. Samples of leaves were oven dried at 70 °C and N, P, K and Ca contents were estimated. Total nitrogen content was determined according to the method described by Jones Jr, [39]. While, total phosphorus content was measured according to Page, et al. [40]. Also, total potassium content was determined according to the method described by Chapman and pratt, [41] and calcium content was measured according to Jackson [42].

Statistical analysis

The obtained data were subjected to the analysis of variance (ANOVA) using the computer program CoStat Version: 6.303 [43]. Means of treatments were compared with the value of revised LSD test at the 5% level of probability.

Results and Discussion

The present study is exploring different approach to use MC for controlling *M. incognita* through direct incorporation of MC into the soil before tomato planting. Data of table 3 demonstrated that all the tested applied treatments reduced the nematode final population (P_f), reproduction factor (Rf), numbers of galls and egg masses of *M. incognita* infected tomato plants under field conditions during both seasons

Table 3: Effect of two kinds of *Pleurotus sajor-caju* spent compost (MCR and MCW) and the chemical nematicide Vydate® (Oxamyl 10% G) on controlling *Meloidogyne incognita* infecting tomato plants during two successive seasons (2016 and 2017).

Treatment	Rate (g/m²)	J_2 / kg soil				G/plant	R	EM/plant	R
		P_i	P_f	R	Rf				
1st season									
MCR	600	4300	2082 b	74.8	0.48	200 b	68.7	180 b	68.8
	1200	3878	1412 c	81.1	0.36	142 cd	77.7	128 c	77.8
MCW	600	4250	1968 b	76.0	0.46	170 c	73.4	162 b	71.9
	1200	4062	1130 cd	85.5	0.28	125 d	80.4	103 d	82.1
Vydate®	5	4106	1024 d	87.0	0.25	107 e	83.2	98 d	83.0
Non-treated	-	3980	7590 a	-	1.91	638 a	-	576 a	-
2nd season									
MCR	600	4080	2186 b	70.0	0.54	221 b	71.7	196 b	68.0
	1200	3740	1320 d	80.2	0.35	164 c	79.0	149 c	75.7
MCW	600	3962	1796 c	74.6	0.45	197 bc	74.7	190 b	69.0
	1200	3658	1012 de	84.5	0.27	133 cd	83.0	116 cd	81.1
Vydate®	5	3680	910 e	86.2	0.24	116 d	85.1	104 d	83.0
Non-treated	-	4056	7150 a	-	1.76	780 a	-	612 a	-

Mean in each column followed by the same letter(s) are not significantly different at $p = 0.05$.
P_i = nematode initial population of J_2/ kg soil; P_f = nematode final population of J_2/ kg soil; R = reduction percentage was calculated using Mulla's formula; (R = 100 - [(C1/T1) × (T2/C2) × 100]); Rf = nematode reproduction factor = (P_f/P_i); G = numbers of galls; EM = numbers of egg masses; MCR: Spent compost of *P. sajor-caju* grown on rice straw substrate, MCW: Spent compost of *P. sajor-caju* grown on wheat straw substrate.

(2016 and 2017). At the 1st season, Vydate® 10 G was the most effective treatment in suppressing P_f in soil, numbers of galls and egg masses by 87, 83.2% and 83%, respectively. Next to Vydate® 10 G treatment, the highest reductions of *M. incognita* P_f in soil (81.1% & 85.5%), (77.7% & 80.4%) nematode root galls and (77.8% & 82.1%) egg masses were recorded with high rate (1200 g) of MCR and MCW treatments as compared to the untreated treatment. While, low application rate (600 g) of MCR and MCW reduced nematode P_f in soil, numbers of galls and egg masses by (74.8 % & 76%), (68.7% & 73.4%) and (68.8% & 71.9%), respectively.

Similar results were obtained in the 2nd season (Table 3). Vydate® 10 G and treatments of (MCR and MCW) at rate of 1200 g/m² showed maximum reductions in soil P_f with (80.2 - 86.2%), numbers of galls (79 - 85.1%) and egg masses (75.7 - 83%) as compared to the untreated plants. Whereas, 600 g of MCR and MCW suppressed nematode P_f by (70% & 74.6%), numbers of galls (71.7% & 74.7%) and egg masses (68% & 69%).

Chemical pesticides mostly have the advantage of the quick and effective response in controlling plant-parasitic nematodes. The obtained results of the present work were confirmed by Saad, et al. [44], who found that oxamyl and fenamiphos were the most effective treatments in controlling the root-knot nematode, *M. incognita* on tomato plants.

However, many alternative strategies have been recently adopted to replace chemical pesticides due to their negative effects on the environment, inducing pest resistance, toxic hazards on human and animal health and high costs [11,12,45,46]. Results of the present study are greatly consistent with the results of several studies which reported that root-knot nematodes could not reproduce in the cultures of *Pleurotus* spp. and confirmed the ability of oyster mushrooms to capture, kill and digest the nematode [47-49]. Barron and Thorn, et al. [50] indicated the oriented/directed growth of the hyphae which then entered, with a great precision the head of nematode as directed hyphae. Oriented hyphae were commonly observed on dead nematodes attacked by the *Pleurotus* species. *P. ostreatus* is known to exude a toxin from their hyphae, known as trans-2-decenedioic acid [51]. This toxin paralyzes the nematodes on contact, which allows the hyphae to move into position to colonize and digest the nematode. *Pleurotus* spp. killed the root-knot nematode after only a short period of exposure to their hyphae. Nematodes were immobilized as soon as they approached the fungal colony [25,50,52,53].

Our results were agreed and supported with many studies emphasized that the root-knot nematodes were greatly suppressed after MC application [24,54-56]. They found that MC was effective as soil amendments in the management of *Meloidogyne* spp. on tomato plants.

Direct incorporation of MC into the soil could ensure direct contact of the mushroom mycelia with nematodes. Palizi, et al. [57] reported that direct incorporation of oyster mushroom compost into the soil at 3% (w/w) suppressed more than 85% of sugar beet cyst nematode (*Heterodera schachtii*) cysts under field conditions. On the other hand, Ching and Wang, et al. [58] reported that direct MC amendment did not suppress *M. incognita* on basil roots in the sandy soil. It is possible that poor establishment of the mushroom mycelium in the soil mix with limited organic matter.

The nematoxic effects of MC may be attributed to the phenolic compounds present in MC, which have antimicrobial activity and could be an effective biocontrol of root-knot nematodes on tomato [24]. Furthermore, Pant and Singh, et al. [59] reported that spent compost of *P. sajor caju* was effective for management and minimise the root galls of *M. incognita* on tomato plants because its mycelium is carnivores, eats nematodes, exudes extracellular toxins that stun the nematodes, where upon the mycelium invades its body through its orifices.

The balanced application of macro and micronutrients to the soil is the best way of ensuring that the crop is able to withstand the damage caused by nematodes [31]. Mushroom compost is a residual byproduct produced by the mushroom industry and a good source of nutrients (0.7% N, 0.3% P, 0.3% K plus a large number of trace elements), as well as a useful soil conditioner [60,61]. Furthermore, a significant effect of MC in our study may be also due to other indirect mechanisms, such as stimulates the activities of soil microorganisms that are antagonistic to plant-parasitic nematodes [62,63]. Also, the decomposition of MC resulted in the accumulation of specific compounds in the soil may have nematicidal effects against nematodes. Nitrogen in ammonium form, present in organic matter, is more prejudicial to nematodes than in nitrate form due to the release of free ammonia (NH_3) into the soil during its decomposition [31,64]. In addition, improved crop nutrition and plant growth following MC amendments use might lead to increase plants tolerance against nematodes [65]. Phosphorus is essential to plant growth and can also influence diseases caused by nematodes. Plants become more resistant when supplied with sufficient quantities of phosphorus and release fewer root exudates and are therefore less attractive to nematodes cutting decreasing the incidence of the diseases. Like other nutrients, calcium must be present in sufficient quantity in the soil, since calcium-deficient plants are more susceptible to nematode attack [31].

Moreover, results of the present study are in general agreement with those reported by Abbasi, et al. [26], who demonstrated that the application of completely spawn run compost significantly reduce *M. javanica* egg mass and population densities in soils treated with spent oyster mushroom compost than non-treated under field conditions and it could be one of the best potential bio control agents. In addition, El-Sherbiny and Awd Allah, et al. [19] showed that treatment with waste residues of *P. ostreatus* cultivation as pre-planting soil biofumigants reduced *M. incognita* galls, egg masses, final population and reproduction factor on susceptible tomato plants under field condition and considerably increased fruit yield.

Noteworthy, El-Saedy, et al. [66] evaluate the efficacy of using rice straw and spent substrate of oyster mushroom (*P. ostreatus*) on citrus nematode (*Tylenchulus semipenetrans*) infecting Valencia orange trees and found that soil amendment with spent mushroom substrate significantly reduced numbers of J_2 of *T. semipenetrans* in soil and numbers of J_2 and females in orange roots and increased orange yield. While, the lowest reduction percentages were recorded with the application rates of rice straw along the two tested growing seasons under field conditions.

Vegetative growth parameters

The effect of two kinds of *P. sajor-caju* spent compost (MCR and MCW) compared to the chemical nematicide, Vydate® (Oxamyl 10% G) on vegetative growth characters of tomato plants are presented in table 4. In general, data confirmed that all treatments during both seasons significantly increased the studied growth parameters as compared with untreated plants. In both seasons, treatment of MCW at application rate of 1200 g/m^2 gave the highest significant increasing effect on vegetative growth values compared with the other treatments. While, the lowest values of vegetative growth recorded with application of Vydate® 10 G during 2016 and 2017 seasons (Table 4).

The present results are in agreement with some previous studies, which indicate the viability of using MC as an organic fertilizer for growing tomato plants [67-69]. Similarly, Pant and Singh, et al. [59] reported that spent compost of *P. sajor caju* was effective for improving tomato growth parameters and soil fertility. Further, the growth parameters were

Table 4: Effect of two kinds of *Pleurotus sajor-caju* spent compost (MCR and MCW) and the chemical nematicide Vydate® (Oxamyl 10% G) on vegetative growth parameters of tomato plants during 2016 and 2017 seasons.

Treatment	Rate (g/m^2)	Fresh weight (g/plant)		Leaf area (cm^2/plant)	Plant fresh weight (g)	Plant dry weight (g)
		Stem	Leaves			
1st season						
MCR	600	230.2 b	742.0 b	1372.0 b	1259.1 b	103.5 b
	1200	272.1 a	769.2 b	1457.2 b	1350.5 b	112.1 a
MCW	600	265.0 a	751.4 b	1450.4 b	1302.3 b	106.8 ab
	1200	297.4 a	832.0 a	1872.1 a	1520.7 a	121.7 a
Vydate®	5	208.5 b	613.6 c	1245.0 c	1135.2 c	91.8 bc
Non-treated	-	185.0 c	541.8 d	872.7 d	981.5 d	80.6 c
2nd season						
MCR	600	262.3 b	735.3 b	1424.1 b	1325.7 b	107.1 ab
	1200	285.0 a	789.7 b	1550.3 b	1402.5 b	116.9 a
MCW	600	295.0 a	784.0 b	1595.0 b	1385.4 b	114.6 a
	1200	319.6 a	886.2 a	2510.5 a	1579.3 a	125.9 a
Vydate®	5	232.2 b	638.3 c	1262.0 c	1186.0 c	94.7 b
Non-treated	-	202.1 c	570.0 d	951.0 d	1003.2 d	90.0 b

Mean in each column, followed by the same letter(s) are not significantly different at p = 0.05, MCR: Spent compost of *P. sajor-caju* grown on rice straw substrate, MCW: Spent compost of *P. sajor-caju* grown on wheat straw substrate.

increased due to quick metabolism of MC, release of nutrients which accelerate rapid root development and over all plant growth of tomato. In addition, mixing MC into the soil can improve organic matter, nutrient availability, water holding capacity, and soil quality which important for improving growth, productivity and quality of tomato [27,70-72].

Fruit number and yield

All the tested treatments, in both seasons, significantly increased ($p \leq 0.05$) the number of fruits/plant, average fruit weight and fruit yield of tomato plants (Table 5). Treatment of MCW at application rate of 1200 g/m^2, gave the maximum fruit yield/plant, as well as the lowest percentage of unmarketable fruits, followed by 600 g of MCW and treatment of MCR at application rates 600 and 1200 g/m^2 during the both seasons. Whereas, the significantly lowest value of fruit yield/plant was recorded with the untreated plant in both seasons. Many authors greatly supported our findings [19,26,59,69]. They found that MC was effective as soil amendments for improving tomato growth performance and fruit yield. Likewise, El-Hadi and Camelia, et al. [73] reported that applying natural organic amendments had a positive effect in increasing tomato yield and decreasing the unmarketable fruit yield.

Fruit quality parameters

The efficacy of applied treatments of MCR, MCW and Vydate® 10 G on total soluble solids (TSS %), acidity (%), vitamin C (mg/g), fruits dry matter (%) and Ca (%) are shown in table 6. The obtained results indicated that values of vitamin C and Ca (%) in tomato fruits significantly increased with treatments of MCR and MCW followed by Vydate® 10 G during 2016 and 2017 seasons. However, no significant difference was observed in fruits dry matter (%) and TSS % among the different treatments during the both seasons. These findings are in agreement with the results of previous studies which reported that the spent mushroom substrate can be used as compost in potting soil mixes for improving tomato fruit quality [74,75]. Likewise, certain reports showed that organic fertilizers such as composts can contribute to the improvement of the nutritional value of vegetable production [76,77].

Leaf chemical composition

Results presented in table 7 showed the effect of MCR, MCW

Table 5: Effect of two kinds of *Pleurotus sajor-caju* spent compost (MCR and MCW) and the chemical nematicide Vydate® (Oxamyl 10% G) on tomato yield component during 2016 and 2017 seasons.

Treatment	Rate (g/m^2)	Number of fruits /plant	Unmarketable fruits (%)	Average fruit weight (g)	Fruit yield g/plant
		1st season			
MCR	600	13.6 b	7.1 c	46.8 ab	675 b
	1200	15.8 ab	6.6 c	51.6 a	722 b
MCW	600	13.9 b	5.8 cd	49.7 ab	687 b
	1200	18.4 a	5.1 d	63.3 a	972 a
Vydate®	5	16.1 a	10.1 b	45.3 b	635 b
Non-treated	-	11.7 c	18.4 a	34.3 b	374 c
		2nd season			
MCR	600	17.8 b	4.5 bc	40.4 ab	660 bc
	1200	19.5 a	3.6 c	45.6 a	735 b
MCW	600	19.3 a	2.7 c	40.9 ab	714 b
	1200	22.5 a	1.8 d	51.6 a	1007 a
Vydate®	5	18.3 ab	6.5 b	39.1 b	650 c
Non-treated	-	13.4 c	16.9 a	30.8 c	369 d

Mean in each column, followed by the same letter(s) are not significantly different at $p = 0.05$, MCR: Spent compost of *P. sajor-caju* grown on rice straw, MCW: Spent compost of *P. sajor-caju* grown on wheat straw.

Table 6: Effect of two kinds of *Pleurotus sajor-caju* spent compost (MCR and MCW) and the chemical nematicide Vydate® (Oxamyl 10% G) on chemical quality, dry matter (%) and Ca (%) of tomato fruits during 2016 and 2017 seasons.

Treatment	Rate (g/m^2)	TSS (%)	Acidity (%)	Vitamin C (mg/g)	Dry matter (%)	Ca (%)
			1st season			
MCR	600	7.60 a	0.74 a	88.32 a	5.30 a	0.24 a
	1200	7.70 a	0.78 a	89.40 a	5. 35 a	0.21 a
MCW	600	7.50 a	0.66 b	87.20 a	5.29 a	0.22 a
	1200	8.20 a	0.77 a	88.76 a	5. 40 a	0.29 a
Vydate®	5	7.50 a	0.77 a	84.11 b	5.40 a	0.15 b
Non-treated	-	8.00 a	0.85 a	84.50 b	5.48 a	0.14 b
			2nd season			
MCR	600	7.60 a	0.65 b	86.57 a	5.27 a	0.21 a
	1200	7.50 a	0.70 a	88.60 a	5.20 a	0.23 a
MCW	600	7.40 a	0.61 b	87.50 a	5.23 a	0.23 a
	1200	7.80 a	0.69 b	89.58 a	5.42 a	0.26 a
Vydate®	5	7.30 a	0.71 a	83.20 b	5.36 a	0.12 b
Non-treated	-	7.50 a	0.78 a	83.34 b	5.39 a	0.12 b

Mean in each column, followed by the same letter(s) are not significantly different at $p = 0.05$, MCR: Spent compost of *P. sajor-caju* grown on rice straw substrate, MCW: Spent compost of *P. sajor-caju* grown on wheat straw substrate.

Table 7: Effect of two kinds of *P. sajor-caju* spent compost (MCR and MCW) and the chemical nematicide Vydate® (Oxamyl 10% G) on leaf chemical composition of tomato plants during 2016 and 2017 seasons.

Treatment	Rate (g/m²)	N	P	K	Ca	Chlorophyll (mg/g)
		%				
1st season						
MCR	600	4.35 a	0.35 a	3.67 b	1.78 b	47.5 a
	1200	4.90 a	0.38 a	3.79 a	1.94 b	47.9 a
MCW	600	4.15 a	0.34 a	3.70 b	1.85 b	48.3 a
	1200	4.80 a	0.35 a	3.84 a	2.57 a	49.6 a
Vydate®	5	3.60 b	0.31 ab	3.60 b	1.63 b	44.6 a
Non-treated	-	3.50 b	0.30 b	3.50 c	1.01 c	40.2 b
2nd season						
MCR	600	4.60 a	0.34 a	3.69 b	1.83 b	46.2 a
	1200	5.00 a	0.37 a	3.74 a	1.86 b	48.6 a
MCW	600	4.50 a	0.33 a	3.71 a	1.87 b	47.5 a
	1200	4.70 a	0.35 a	3.81 a	2.63 a	48.8 a
Vydate®	5	3.75 b	0.30 b	3.63 b	1.60 b	45.4 a
Non-treated	-	3.70 b	0.30 b	3.52 c	1.04 c	40.4 b

Mean in each column, followed by the same letter(s) are not significantly different at p = 0.05, MCR: Spent compost of *P. sajor-caju* grown on rice straw substrate, MCW: Spent compost of *P. sajor-caju* grown on wheat straw substrate.

and the chemical nematicide, Vydate® 10 G on leaf chemical composition of tomato plants during the two successive seasons. Data showed that treatments of MCR and MCW in both seasons, gave significantly the highest percentages in both leaf nitrogen and phosphorus contents as compared to the untreated plants. Generally, the results clearly indicated that the assessed treatments had a positive effect on leaf contents of N, P, K and Ca % in tomato plants and significantly improved nutritional status to optimum sufficient ranges with a rise in leaves chlorophyll content as compared to the untreated plants in both seasons (Table 7).

The amount and type of nutrients supplied to tomato can influence not only its yield but also its nutrient content, taste, and post-harvest storage quality. Nutrient elements, such as N, P, K, Ca and Mg are needed in large amounts for normal growth and reproduction. While other elements, such as Fe, Cu, Zn, Mn, B and Mo are needed in small amounts for nutritionally "healthy" plants and proper crop nutrition [78]. Leaf composition is the best indicator of the nutritional status of plants [79]. The judicious rationalized use of chemical fertilizers in agricultural production is critical for improving production efficiency and a sustainable ecosystem [70]. Organic soil amendments can increase soil organic matter and improve chemical and physical soil properties with improving soil fertility which in turn promotes improved crop [62,80,81]. MC can be a useful tool for improving soil health by providing organic matter and supplies a lot of nutrient elements like nitrogen, phosphorus and potassium for the healthy growth of plants. It has also been shown to have high water holding capacity, which decrease water used for irrigation [26,82]. Overall, MC was suitable as a natural fertilizer and soil amender in vegetable fields and can contribute to the improvement of the nutritional value of tomato production [61,76].

Conclusion

Recently, the use of MC as a soil amendment has received increasing attention for soil reclamation. MC provides promising results in suppressing root-knot nematodes and has been given a lot of attention by researchers due to their environmentally safe and economically satisfactory solution. Finally, results of our experiments confirmed the nematicidal potential of *P. sajor-caju* spent compost as an effective biocontrol treatment for management of *M. incognita* on tomato, also improved nutritional status and significantly enhanced fruit yield expressed as weights or numbers. Thus, addition of MC to the soil can be one of the best eco-friendly alternative practices for controlling root-knot nematodes and increasing vegetable productivity.

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