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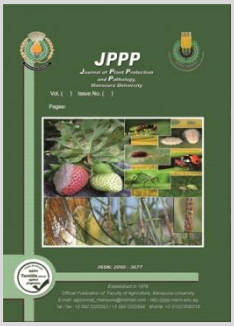
Effect of Certain Soil Amendments on Root-Knot Nematode, *Meloidogyne javanica*, Affecting Eggplant

El-Shaefeey E. I.[1*]; M. A. El-Sheikh[2] ; A. A. El-Khatieb[2] and H. M. Heikal[2]

[1]Department of Agricultural Botany, [(2)]Faculty of Agriculture, Kafrelsheikh University, Egypt
[2]Plant Pathology Department, [(2)]Faculty of Agriculture, Damanhour University, Egypt



ABSTRACT

Meloidogyne javanica was recovered from eggplant galled roots sampled from El-Nubaria region, El-Beheira Governorate, Egypt. In pot experiments, soil amendments i.e. a mixture of cabbage, turnip and raddish seeds powder, zingiber powder, pomegranate peels powder and doves manure significantly reduced galls and egg masses numbers/root system, eggs number/1g root and second stage juveniles (J2s) number/250g soil on eggplant cultivars Laeli2hybrid and Black long grown in soil infected with *Meloidogyne javanica.* Results revealed that doves manure was the most effective and reduced disease parameters. On the other hand, chlorophyll b and total chlorophyll contents were significantly raised in leaves of eggplant cv. Black long with the introduction of cabbage, turnip and raddish seeds powder, zingiber powder, pomegranate peels powder and doves manure a week prior nematode inoculation. Also, eggplant growth parameters (fresh and dry shoot and root lengths and weights) were significantly improved with all tested amendments. Such treatments significantly raised catalase (CAT), polyphenoloxidase (PPO) and peroxidase (PO) activity in eggplant leaves compared to infected control.

***Keywords*:** *Solanum melongena*, *Meloidogyne javanica*, soil amendments, galls number, total chlorophyll, enzymes activity.

INTRODUCTION

Eggplant (Solanum melongena L.) belongs to Solanaceae family. About 54 million tons of fresh eggplant were produced round the world in 2018 (FAO, 2018). Eggplants contain many nutrients such as C, K, B6, niacin, thiamin and nutrients like magnesium, phosphorous, copper, dietary fiber, folic acid, potassium, and manganese. Eggplants contain high antioxidants, may reduce the heart disease, prevent sugar blood and help in loss human weight. There is almost no cholesterol and may prevent from cancer (Rachael, 2017).

Plant parasitic nematodes are a major problem for growers worldwide, causing severe crop losses in the yield every year in infected crops (Kiewnick and Sikora, 2005; Crow, 2007; Pulavarty et al. 2021). In Egypt, plant parasitic nematodes especially root-knot nematode (Meloidogyne spp.) considered as one of the most important agricultural pest for many economic fields and vegetable crops (Ibrahim et al., 2010; 2014).

Soil amendments such as animal and green manures, cover crops, crop residues, straws, etc. are used to improve soil and plant health that leads to sustainable agriculture (Rizvi *et al.*, 2015; Akram *et al*., 2016; Ansari *et al*., 2017). Various plant diseases caused by soil borne pathogens became more aggressive to their host plants. Therefore, great interest was directed to find an eco-friendly efficient method to reduce these pathogens effect. Organic soil amendments may introduce a successive method for that.

Using organic amendments such as composts, agricultural and other industrial wastes, crop residues and plant derivatives to control plant-parasitic nematodes has been reported in voluminous reports (Rahman *et al*., 2011; Abolusoro *et al*., 2013; Rizvi *et al*., 2018). Rizvi *et al.* (2018) indicated that organic soil amendments increased plant growth, biomass,chlorophyll and nutrient status(N, P and K).

Brassica carinat soil amendments, Medicago sativa dry biomass and Beta vulgaris pressed pulp significantly decreased M. incognita populations on tomato roots (cv. Regina) grown in potted soil compared to untreated control and Oxamyl nematicide applied at rates of 10, 20, 30 or 4o g/kg. Also, tomato plant growth was increased up to up to the rate of 30g/kg soil and tomato yield significantly improved than untreated control at rate of 10 g/kg (D'Addabbo *et al*., 2020)

Abdel-Monaim *et al.* (2018) mentioned that organic soil amendments enhanced defense enzymes activity (peroxidase (PO), polyphenol oxidase (PPO) and phenylalanine ammonia lyase (PAL), pathogenesis related protein (chitinase and β 1, 3 gluconase) and total phenol contents more than applied individually in cowpea forage plants infected with, M.incognita under greenhouse conditions.

Present study therefore was conducted to study efficacy of newly introduced, eco-friendly materials against M.javanica affecting eggplant plants through following approaches: 1-Efficacy of soil amendments on eggplant disease parameters caused by M. javanica,, 2-Soil amendments effect on eggplant growth parameters and enzyme activity. 3-Oil amendments effect on eggplant chlorophyll a, b and total chlorophyll concentration.

MATERIALS AND METHODS

Studies were conducted in both Faculty of Agriculture, Damanhour University as well as Faculty of

* **Corresponding author.**
E-mail address: elshafeeyi@yahoo.com
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Agriculture, Kafrelsheikh University during the 2018 – 2019 summer seasons to investigate the efficacy of some newly soil organic amendments against Meloidogyne javanica affecting eggplant.

Nematode culture

Eggplant galled roots were collected from naturally infected plants from El-Nubaria region, El-Beheira Governorate during the 2018 summer season and nematode was isolated and identified as Meloidogyne javanica on the perineal pattern basis for mature females according to Seinhorst (1966) and Alkhateb (2014) key.

For pure culture, a single egg mass was collected from infected eggplant and cultured on Baermann dish (10-cm in diameter) in distilled water for three days at 28 ± 2 C°. Hatched juveniles from single egg mass were inoculated to eggplant already planted in sterilized soil. Individual egg mass population was subcultured periodically at 45 – 60 days with the replacement intervals for old plants by new eggplant seedlings. This renewal provided the constant and large supply of second stage juveniles (J2s) and egg masses. Root-knot nematode (M. javanica) eggs were extracted from galled eggplant roots using 0.5% sodium hypochlorite solution (NaOCl) according to Hussey and Barker (1973).

Eggplant seedlings preparation

Two weeks old seedlings of eggplant cultivars Laeli2hybrid (purple white long) and Black long, (Black long) were obtained from El-Bostan region, El-Beheira Governorate, then grown in peat moss for two weeks, under greenhouse conditions, fertilized and watered as usual.

Soil amendments sources

Dried commercial cabbage (Brassica oleracea capitat), turnip (Brassica rapa) and radish (Raphanus sativus) seeds were obtanied form seed shop and crushed to obtain the mixed powder, Pomegranate peels (Punica granatum) and Zingiber (Zingiber officinalis) powders were obtained from commercial markets and doves manure was obtained from own doves farm.

Experimental design

Eggplant seedlings (four weeks old) of Laeli2hybrid (purple white long) and Black long, (Black long) cultivars were transplanted in 25-cm diameter plastic pots filled with 3 kg sterilized loamy sand soil (1:3 v/v). Thirty gram of selected soil amendments and fenamiphos-400 (1.5 ml/L) were separately added to 3 kg sterilized loamy sand soil (1:3 v/v) before eggplant seedlings. One week after eggplant seedlings, approximately 5000 eggs and newly hatching second stage juveniles suspension/pot were added to the soil in 3-holes surrounding stem base.

Pots containing eggs and newly hatching second stage juveniles) served as positive control. Pots were maintained for 70 days from inoculation, under greenhouse conditions. The experiment was carried out in a complete randomized design with 6 treatments and 3 repetitions for each eggplant cultivar. Treatments were as follows; 1. Cabbage, turnip and raddish seeds powder; 2. Pomegranate peels powder; 3. Zingiber powder; 4. Doves manure;5. Fenamiphos-400 and 6. Inoculated plants (Control).

Parameters Measurements and Determinations

At the end of experiment, 70 days after seedlings, plants were harvested and evaluated for nematode and growth parameters, chlorophyll content and enzymes activity.

Nematode parameters

Galls were stained in phloxine B (0.15g/L tap water) for 15-20 min according to Taylor and Sasser (1978) and number of galls and egg masses /root system were recorded. Eggs number per gram root tissue was recorded by using 0.5% sodium hypochlorite solution according to Hussey and Barker (1973). Also, juveniles number (J2s)/250g soil was recorded using modified Cobb's sieving and Modified Baermann technique (Christie and Perry, 1951).

Growth parameters

Eggplant shoots were cut off and roots gently removed and washed to be free of soil. Roots and shoots fresh weights (g) and lengths (cm) were measured. Also, dry weight of the root and shoot systems were measured by cutting plant parts into pieces and dried in vacuum hot air oven for 2-3 days at 80 C° until constant weight.

Chlorophyll concentration determinations

Chlorophyll (Chl.) concentration as mg/g fresh weight of one gram fresh leaves were extracted with 5 ml dimethyl-formamid for overnight at 5 C° then estimated chlorophyll a and b. spectrophotometerically at 663 and 647 nm as described by Moran and Porath (1982). The concentration was calculated in the following equations:

$$\textbf{Chl.a} = 12.76\ A_{663} - 2.79\ A_{647}\ \textbf{(mg/l)},$$

$$\textbf{Chl. B} = 20.76\ A_{647} - 4.62\ A_{663}\ \textbf{(mg/l)}.$$

$$\textbf{Total Chl.} = 17.9\ A_{647} + 8.08\ A_{663}\ \textbf{(mg/l)}.$$

Enzyme activity determinations

Forty five days from inoculation, 0.5 g leaf material was homogenized at 0 - 4 C° in 3 ml of 50 mM TRIS buffer (pH 7.8), containing 1 mM EDTA-Na2 and 7.5% polyvinylpyrrolidone. The homogenates were centrifuged (12,000 rpm, 20 min, 4 C°), and the total soluble enzyme activities were determined spectrophotometrically in the supernatant (Hafez, 2010). All determinations were carried out at 25 C°, using the model UV-160A spectrophotometer (Shimadzu, Japan).

Catalase (CAT) activity assay

Catalase (CAT) activity was determined spectrophotometrically according to Aebi (1984). Changes in absorbance at 240 nm were recorded every 30 sec intervals for min. enzyme activity was expressed as the increase in absorbance min-1g-1 fresh weight.

Polyphenol oxidase (PPO) activity assay

Polyphenol oxidase (PPO) activity was determined according to Malik and Singh (1980). Changes in the absorbance at 495 nm were recorded every 30 sec intervals for 3 min. enzyme activity was expressed as the increase in absorbance min-1g-1 fresh weight.

Peroxidase (PO) activity assay

Peroxidase (PO) activity was directly determined the crude enzyme extract according to a typical procedure proposed by Hammerschmidt *et al*. (1982). Changes in absorbance at 470 nm were recorded every 30 sec intervals for 3 min. enzyme activity was expressed as the increase in absorbance min-1 g-1 fresh weight.

Statistical analysis

Obtained data were statistically analyzed using costat version 6400win statistical software. Comparison between means was carried out using LSD at 5% level of probability. Numbers of galls, egg masses per root system, number of eggs/1g root and number of juveniles (J2s)/250g soil were transformed to $\sqrt{x+1}$ before statistical analysis.

RESULTS AND DISCUSSION

Results

Efficacy of different soil amendments applied a week prior inoculation on eggplant disease parameters–Soil amendments effect on galls number/root system

Data in Table (1) and Fig. (1) indicated that treatments were significantly ($p \leq 0.05$) different in galls number per plant compared to control (plants inoculated with nematode only). However, doves manure was the most effective and declined number of galls/roots system by 3.63 and 2.12 for cv. Laeli2hybrid and cv. Black long, respectively compared to 17.91 and 16.50 for infected control, followed by a mixture of cabbage, turnip and radish seeds and Zingiber powders with significant differences compared to doves manure treatment.

However, pomegranate peels powder had the third grade in both cultivars, with values still significant lower (15.39 and 11.92, respectively) than infected control, but was not significant for galls number/roots with a mixture of cabbage, turnip and radish seeds powder in cv. Black long. Meanwhile, fenamiphos-400 significantly reduced galls number/roots on eggplant cv. Laeli2hybrid and cv. Black long, compared to other treatments and infected control.

Soil amendments effect on egg masses number/root system

Data presented in Table (2) and Fig. (2) showed that soil amendments significantly reduced egg masses number in eggplant cultivars Laeli2hybrid and Black long. Doves manure was the most effective as decreases egg masses number to be 2.05 and 1.80 on eggplant cvs., respectively, compared to 13.77 and 12.05 for infected control, followed by a mixture of cabbage, turnip and radish powder with significant differences compared to doves manure.

However, pomegranate peels and zingiber powder had the third grade for both cultivars with values still significant lower than infected control. Meanwhile, fenamiphos-400 was the best treatment that no egg masses were recorded on eggplant cvs., compared to other treatments and infected control.

Soil amendments effect on eggs number/1g root

Table (1) and Fig. (3) indicated that soil amendments treatments significantly reduced eggs number/1g root for eggplant cultivars (Laeli2hybrid and Black long) in trend similar to that obtained for galls and egg masses number/root system. The most effective treatment was doves manure which significantly decreased eggs number/1g roots by 31.84 and 36.34 on eggplant cultivars, respectively, compared to 282.15 and 299.37 for infected control. Followed by a mixture of cabbage, turnip and radish seeds powder with no significant differences compared with doves manure.

However, pomegranate peels and zingiber powder had the third grade with both cultivars with values still significant lower than infected control, but were not significant in cv. Laeli2hybrid. where eggs number/1g roots was 92.43. Meanwhile, fenamiphos-400 significantly reduced eggs number/1g root being 0.00 on eggplant cultivars compared to other treatments and infected control.

Table 1. Effect of soil amendments, applied a week prior *Meloidogyne javanica* inoculation, on nematode parameters of eggplant cultivars.

Parameters	No. of galls/roots		No. of egg masses/roots		No. of eggs/1g root		No. of junveniles (J_2s)/250g soil	
Cultivars Treatments	cv. Laeli2 Hybrid	cv. Black long	cv. Laeli2Hybrid	cv. Black long	cv. Laeli2Hybrid	cv. Black long	cv. Laeli2 Hybrid	cv. Black long
Cabbage, Turnip and Raddish seeds powder	9.32^{c}	9.89^{bc}	6.10^{c}	6.88^{b}	111.53^{c}	47.42^{c}	7.38^{d}	6.13^{bc}
Doves manure	3.63^{d}	2.12^{d}	2.05^{d}	1.80^{c}	31.84^{d}	36.34^{cd}	9.02^{cd}	5.76^{bc}
Fenamiphos-400	0.00^{e}	0.00^{d}	0.00^{e}	0.00^{c}	0.00^{e}	0.00^{d}	0.00^{e}	0.00^{c}
Infected control (Inoculated plants)	17.91^{a}	16.50^{a}	13.77^{a}	12.05^{a}	282.15^{a}	299.37^{a}	43.25^{a}	51.82^{a}
Pomegranate peels powder	15.39^{b}	11.92^{b}	8.94^{b}	9.19^{b}	92.43^{c}	88.41^{b}	12.21^{c}	11.47^{b}
Zingiber powder	10.99^{c}	8.51^{c}	9.85^{b}	8.82^{b}	139.54^{b}	121.45^{b}	27.22^{b}	9.97^{b}

Values followed by different letter(s), for each single parameter, are significantly different at ($p \leq 0.05$).

Soil amendments effect on juveniles (J_2s) number/250g soil

In Table (4) and Fig. (4) soil amendments treatments were significantly ($p \leq 0.05$) different compared to control for J2s number/250g soil in eggplant cv. Black long and were not significant within treatments. But, with eggplant cv. Laeli2hybrid, treatments were significantly ($p \leq 0.05$) different compared to control and fenamiphos-400 for juveniles (J2s) number/250g soil. Cabbage, turnip and raddish seeds powder (7.38) was the most effective compared to infected control (43.25), followed by doves manure (9.02) with no significant differences for the cultivar.

However, pomegranate peels powder had the third grade with values still lower than infected control. Meanwhile, zingiber powder had the last grade and significantly different compared to infected control for both cultivars.

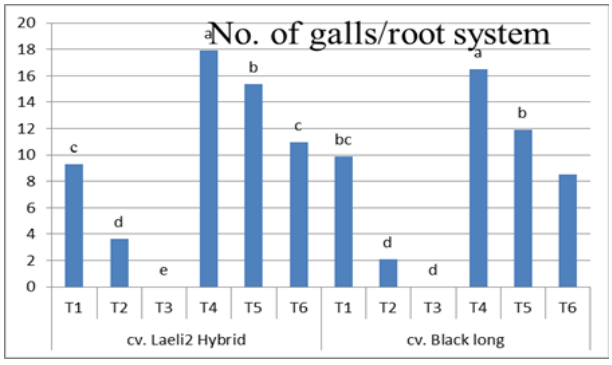

Fig. 1. Effect of soil amendments, applied a week before inoculation, on eggplant No. of galls/root system. T1: Cabbage, Turnip and Raddish seeds powder, T2: Doves manure, T3: Fenamiphos-400, T4: Infected untreated control (Inoculated plants), T5: Pomegranate peels powder, T6: Zingiber powder.

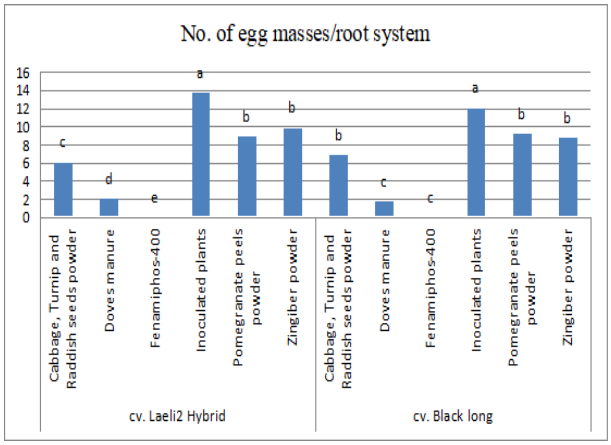

Fig. 2. Effect of soil amendments applied a week prior inoculation on eggplant No. of egg masses/root system.

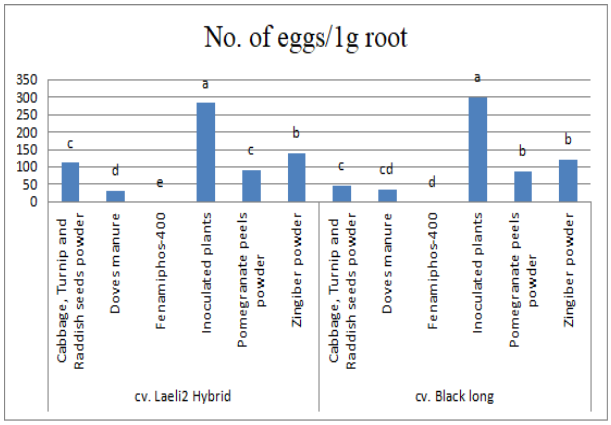

Fig. 3. Effect of soil amendments applied a week prior inoculation on eggplant No. of eggs/1g root.

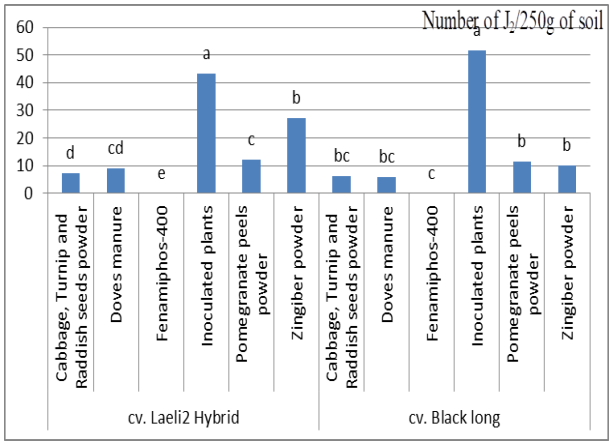

Fig. 4. Effect of soil amendments applied a week prior inoculation on eggplant J_2 number /250g soil.

Efficacy of soil amendments applied a week priozr inoculation on eggplant gowth parameters

Soil amendments effect on root system

Data presented in Table (2) showed that a mixture of cabbage, turnip and raddish seeds powder significantly enhanced root traits values for cultivars Laeli2hybrid and Black long. Concerning cv. Laeli2hybrid, average of fresh root weight with cabbage, turnip and raddish seeds powder was 32.68 compared to 11.01 for infected control. Meanwhile, pomegranate peels powder significantly ranked the least compared to control.

But, other treatments and nematicide were not significant different compared to infected control. Same trend was revealed in case of dry root weight. For both eggplant cultivars, all treatments showed no significant improvement for root length values compared to infected control.

Table 2. Effect of soil amendments, applied a week prior *Meloidogyne javanica* inoculation, on eggplant growth parameters.

Parameters	Root system			Shoot system		
	Root weight (g)		length (cm)	Shoot weight (g)		length (cm)
	Fresh	Dry		Fresh	Dry	
Cultivars Treatments			cv. Laeli2hybrid			
Cabbage, Turnip and Raddish seeds powder	32.6^{a}	10.6^{a}	24.0^{a}	72.45^{a}	18.17^{a}	37^{a}
Pomegranate peels powder	4.6^{cd}	1.28^{cd}	23.0^{a}	3.49^{b}	0.87^{b}	13.6^{b}
Zingiber powder	6.9^{bcd}	2.27^{bcd}	26.3^{a}	16.42^{b}	4.11^{b}	37.3^{a}
Doves manure	9.1^{bc}	2.9^{bc}	34^{ab}	19.72^{b}	4.94^{b}	29.3^{ab}
Fenamiphos-400	3.9^{d}	1.2^{d}	31.6^{a}	7.33^{b}	1.8^{b}	23.5^{ab}
Infected control (Inoculated)	11.0^{b}	83.5^{b}	32.6^{a}	8.61^{b}	2.16^{b}	22.3^{ab}
	cv. Black long					
Cabbage, Turnip and Raddish seeds powder	36.1^{a}	9.4^{a}	26.3^{ab}	39.5^{a}	8.2^{a}	39^{a}
Peel pomegranate powder	4.1^{d}	1.0^{d}	42^{a}	4.6^{b}	0.9^{b}	20.1^{a}
Zingiber powder	4.6^{d}	1.2^{d}	27.3^{ab}	2.0^{b}	0.5^{b}	24.3^{a}
Doves manure	13.5^{bc}	3.6^{bc}	24.6^{ab}	33.77^{a}	7.10^{a}	39.0^{a}
Fenamiphos-400	5.4^{cd}	1.3^{cd}	21^{b}	7.51^{b}	1.8^{b}	23.0^{a}
Infected control (Inoculated)	15.21^{b}	3.9^{b}	22.3^{ab}	4.48^{b}	0.9^{b}	25.0^{a}

Parameters	Root system			Shoot system		
	Root weight (g)		length (cm)	Shoot weight (g)		length (cm)
	Fresh	Dry		Fresh	Dry	
Cultivars Treatments			cv. Laeli2hybrid			
Cabbage, Turnip and Raddish seeds powder	32.6^{a}	10.6^{a}	24.0^{a}	72.45^{a}	18.17^{a}	37^{a}
Pomegranate peels powder	4.6^{cd}	1.28^{cd}	23.0^{a}	3.49^{b}	0.87^{b}	13.6^{b}
Zingiber powder	6.9^{bcd}	2.27^{bcd}	26.3^{a}	16.42^{b}	4.11^{b}	37.3^{a}
Doves manure	9.1^{bc}	2.9^{bc}	34^{ab}	19.72^{b}	4.94^{b}	29.3^{ab}
Fenamiphos-400	3.9^{d}	1.2^{d}	31.6^{a}	7.33^{b}	1.8^{b}	23.5^{ab}
Infected control (Inoculated)	11.0^{b}	83.5^{b}	32.6^{a}	8.61^{b}	2.16^{b}	22.3^{ab}
	cv. Black long					
Cabbage, Turnip and Raddish seeds powder	36.1^{a}	9.4^{a}	26.3^{ab}	39.5^{a}	8.2^{a}	39^{a}
Peel pomegranate powder	4.1^{d}	1.0^{d}	42^{a}	4.6^{b}	0.9^{b}	20.1^{a}
Zingiber powder	4.6^{d}	1.2^{d}	27.3^{ab}	2.0^{b}	0.5^{b}	24.3^{a}
Doves manure	13.5^{bc}	3.6^{bc}	24.6^{ab}	33.77^{a}	7.10^{a}	39.0^{a}
Fenamiphos-400	5.4^{cd}	1.3^{cd}	21^{b}	7.51^{b}	1.8^{b}	23.0^{a}
Infected control (Inoculated)	15.21^{b}	3.9^{b}	22.3^{ab}	4.48^{b}	0.9^{b}	25.0^{a}

Values followed by different letter(s), for each single parameter, are significantly different at ($p \leq 0.05$).

Soil amendments effect on shoot system

Data presented in Table (2) showed that a mixture of cabbage, turnip and raddish seeds powder treatment significantly enhanced shoot traits values in both cultivars (Laeli2hybrid and Black long). Data for fresh, dry shoot weight (g) and its length (cm) showed trends close to root parameters cv. Laeli2hybrid, however, there were significant differences between cabbage, turnip and raddish seeds powder (37.0cm) and pomegranate peels powder(13.66cm) for shoot length of eggplant infected with *M.javanica*.

Similar trends were observed with eggplant cv. Black long with no significant differences between doves manure (30g/pot) and cabbage, turnip and raddish seeds powder treatments for fresh and dry shoot weights, recorded 70 days after seedlings.

Efficacy of soil amendments, applied a week before inoculation, on eggplant chlorophyll concentration.

Soil amendments effect on chlorophyll A (mg/l) concentration

In Table (3) data presented indicated that there were no significant differences increase in chlorophyll A (mg/l) concentration between treatments compared to inoculated control for eggplant cultivars, Laeli2hybrid and Black long. But, there were significant differences in chlorophyll A (mg/l) con. between pomegranate peels powder and infected control with averages of 41.15 and 41.30 for cv. Laeli2hybrid.

Meanwhile, there were significant differences between fenamiphos-400 (1.5cm3/L) and doves manure (30g/pot) for chlorophyll A (mg/l) con. with values of 41.43 and 41.04, respectively, for eggplant cv. Black long.

Soil amendments effect on chlorophyll B (mg/l) concentration

In Table (3) there were no significant increase in chlorophyll B (mg/l) concentration between treatments compared to infected control and nematicide for cultivar Laeli2hybrid unless cabbage, turnip and raddish seeds powder which had the lowest significant value 23.59 in chlorophyll B (mg/l) concentration compared to other treatments. On the contrary, there were significant increase in chlorophyll B (mg/l) con. values with cv. Black long for soil amendments treatments.

Data for chlorophyll B (mg/l) showed that pomegranate peels powder (30.89) had the highest chlorophyll B (mg/l) concentration compared to infected control (28.10) cv. Black long. That was followed by zingiber powder and doves manure with values of 30.33 and 30.44, respectively, with no significant values compared to pomegranate peels powder. Cabbage, turnip and raddish seeds powder and fenamiphos-400 treatments had the third grade with values of 29.91 and 29.84, respectively compared to infected control (28.10).

Soil amendments effect on total chlorophyll (mg/l) concentration

Data presented in Table (3) showed that there were no significant differences for total chlorophyll concentration (mg/l) in eggplant cv, Laeli2hybrid between pomegranate peels, zingiber powders and doves manure compared to inoculated control and nematicide (fenamiphos-400). followed by cabbage, turnip and raddish seeds powder with total chlorophyll con. (mg/l) 49.09 compared to infected control (50.91) and nematicide. Also, for cv. Black long similar trends were obtained for chlorophyll B with significant differences between treatments and infected control.

Efficacy of soil amendments applied a week before inoculation on eggplant enzyme activity

Catalase enzyme

Table 3. Effect of soil amendments, applied a week prior *Meloidogyne javanica* inoculation, on eggplant chlorophyll A, chlorophyll B and total chlorophyll concentration.

Parameters	Chlorophyll A (mg/l)		Chlorophyll B (mg/l)		Total chlorophyll (mg/l)	
Cultivars	cv.	cv.	cv.	cv.	cv.	cv.
Treatments	Laeli2 hybrid	Black long	Laeli2 hybrid	Black long	Laeli2 hybrid	Black long
Cabbage, Turnip and Raddish seeds powder	42.12^{a}	41.33^{ab}	23.59^{b}	29.91^{b}	49.09^{b}	50.57^{b}
Pomegranate peels powder	41.15^{b}	41.29^{ab}	29.73^{a}	30.89^{a}	50.26^{a}	51.46^{a}
Zingiber powder	41.30^{a}	41.33^{ab}	30.67^{a}	30.33^{ab}	51.27^{a}	50.94^{ab}
Doves manure	41.30^{a}	41.04^{b}	28.93^{a}	30.44^{ab}	49.75a	50.91^{ab}
Fenamiphos- 400	39.95^{ab}	41.43^{a}	30.14a	29.84^{b}	49.77^{a}	50.65^{b}
Infected control (Inoculated)	41.30^{a}	41.21^{ab}	30.26^{a}	28.10^{c}	50.91^{a}	48.88^{c}

Values followed by different letter(s), for each single parameter, are not significantly different at ($p \leq 0.05$).

Data in Table (4) revealed that catalase activity significantly raised with a mixture of cabbage, turnip and raddish seeds powder (483.03) compared to infected control (3.58) in cv. Laeli2hybrid. That was followed by pomegranate peels powder with no significant differences between cabbage, turnip and raddish seeds powder and infected control. However, Zingiber powder (31.51) and doves manure (58.76) exhibited the third grade in eggplant cv. Laeli2hybrid, with not significant compared to infected control.

Meanwhile, the effect of cabbage, turnip and raddish seeds powder was not significantly different from fenamiphos-400 in eggplant cv. Laeli2hybrid. On the contrary, soil amendments treatments were not significantly increased catalase activity in eggplant cv. Black long compared to infected control and phenamiphos. The highest value was recorded cabbage, turnip and raddish) seeds powder with no significant different compared to infected control and fenamiphos-400. The lowest value was insignificantly recorded with doves treatment.

Effect on oxidative enzymes

Data presented in Table (4) showed that zingiber powder significantly raised polyphenol oxidase activity (PPO) in eggplant leaves cv. Laeli2hybrid with average 0.031 (ab./min/g)fw), compared to 0.012 (ab./min/g fw) for inoculated control. That was followed by cabbage, turnip and raddish seeds treatment, No significant differences was indicated with pomegranate peels powders and doves manure and zingiber powder. Meanwhile, Zingiber powder effect was not significantly different compared to fenamiphos-400 (0.003).

But, in eggplant cv. Black long, pomegranate peels powder significantly increased polyphenol oxidase activity (PPO) in leaves with average 0.043(ab./min/g fw), compared to 0.006 (ab./min/g fw) for infected control. Followed by doves manure treatment with no significant differences with pomegranate peels powder. However, cabbage, turnip and raddish seeds powder had the third grade as showed non significant value (0.006) compared with infected control. Zingiber powder had the least grade (0.0006).

In case of peroxidase activity (PO), pomegranate peels powder (0.051) only had significantly raised PO activity compared to infected control (0.009) of eggplant cv. Laeli2hybrid.

Table 4. Effect of soil amendments, applied a week prior *Meloidogyne javanica* inoculation, on eggplant catalase (CAT), polyphenol oxidase (PPO) and peroxidase (PO) activity.

Parameters	Catalase activity (absorption 240/min/gfw)		Polyphenol oxidase activity (absorption495/min/gfw)		Peroxidase activity (absorption470/min/gfw)	
Cultivars	**cv.**	**cv.**	**cv.**	**cv.**	**cv.**	**cv.**
Treatments	**Laeli2 hybrid**	**Black long**	**Laeli2 hybrid**	**Black long**	**Laeli2 hybrid**	**Black long**
Cabbage, Turnip and Raddish seeds powder	483.03^{a}	123.98^{a}	0.009^{ab}	0.006^{bc}	0.012^{b}	0.016^{a}
Pomegranate peels powder	177.03^{ab}	105.53^{ab}	0.006^{ab}	0.043^{a}	0.051^{a}	0.015^{a}
Zingiber powder	31.51^{b}	17.16^{ab}	0.031^{a}	0.0006^{c}	0.004^{b}	0.006^{a}
Doves manure	58.76^{b}	10.03^{b}	0.009^{ab}	0.027^{ab}	0.006^{b}	0.005^{a}
Fenamiphos- 400	128.98^{ab}	93.16^{ab}	0.003^{b}	0.001^{c}	0.024^{ab}	0.019^{a}
Infected untreated control (Inoculated)	3.58^{b}	65.57^{ab}	0.012^{ab}	0.006^{bc}	0.009^{b}	0.004^{a}

Values followed by different letter(s), for each single parameter, are not significantly different at ($p \leq 0.05$).
However, it was not even significantly different from fenamiphos-400 (0.024).

Discussion

Root-knot nematode is the most damaging plant-parasitic nematodes on vegetables production (Jones *et al*., 2013). In Egypt, eggplant (*Solanum melongena* L.), is an important solanaceous vegetable crop, ~~is~~ known to be extremely susceptible to *Meloidogyne* spp. infection (Abd-El-gawad, 2014). Inoculation with root-knot nematode *Meloidogyne incognita* (1500 J2s/plant) caused a significant reduction in both plant growth (12.5 %) and the yield (11.9 %) for round eggplant cv. Pusa Purple (Khan *et al*., 2012).

Chemical nematicides frequently cause environmental pollution and toxic effects to human, plants, and animals. Certain soil amendments that are environmentally friendly and safe to humans and animals were tested on the root-knot nematode (*Meloidogyne javanica*) eggplant.

Results of the presented study supported this hypothesis since cabbage, turnip and raddish seeds powder, zingiber powder, pomegranate peels powder and doves manure significantly reduced galls number as well as declined egg masses number/root system, eggs number/1g root and juveniles (J2s) number/250g soil on eggplant cultivars Laeli2hybrid and Black long grown in potted soil infected with *M.javanica*, one week prior inoculation compared to infected control.

A week prior inoculation with *M.javanica*, doves manure was the most effective and decreased galls number/root on both cvs. Laeli2hybrid and Black long, compared to infected untreated control. Also, tested soil amendments significantly reduced egg masses number in both eggplant cultivars in a trend similar to that obtained for galls number/root. Doves manure was also the most effective as decreased egg masses number on cvs. Laeli2hybrid and Black long, compared to infected control.

In addition, tested soil amendments significantly decreased eggs number/1g root in eggplant cultivars in a trend similar to that obtained for galls and egg masses number/root. Doves manure being the most effective. Meanwhile, results showed that juveniles (J2) number per 250g soil caused by *Meloidogyne javanica* on screened eggplant cultivars significantly decreased with tested soil amendments. Cabbage, turnip and raddish seeds powder was the most effective followed by doves manure.

Meanwhile, the results are in agreement with Pakeerathan *et al*. (2009) who reported that soil amendments effect on *M.javanica* disease parameters was explained in view that soil amendments decrease the nematode root infection by various ways such as act as physical barrier to nematode movement, change root microflora diversity and their population and change physical and chemical properties soil.

In addition, McSorley (2011) pointed that organic soil amendments have been widely used for plant-parasitic nematodes management. Relatively rapid reduction in nematode population levels may occur when decomposing materials release toxic compounds, while longer-term effects might include rises in nematode antagonists. Improved crop nutrition and plant growth following amendment use may lead to plant-parasitic nematodes tolerance.

In this respect, Peiris *et al*. (2020) showed that incorporating organic soil amendments reduced RKN numbers and damage levels by about 63% compared to unamended control. In general, organic soil amendments could reduce both soil RKN numbers and eggs/egg mass number by 73% and root galling by 47% compared to untreated infected control. Results revealed that adding different rates of dry crushed pomegranate peels significantly ($p \leq 0.05$) affected the nematode parameters. The higher rate of peels residue attained higher percentage of nematode reduction. Using a moderate rate (6.0 g/pot) of crushed pomegranate peels decreased nematode criteria based on the intervals times at which the peels were added before transplanting. A negative relationship was found between the time of the tested substance addition and the percentage of nematode reduction.

Present study showed that treatment with a mixture of cabbage, turnip and raddish seeds) powder significantly improved growth parameters (root and shoot fresh weight and root and shoot dry weight) compared to infected control, applied a week, prior inoculation with *M. javanica.*

Present results also are in agreement with Faruk (2019) who reported that different organic soil amendments were effective to *Meloidogyne* spp. infection. All treatments have gall development reduction on roots and enhanced plant growth as well as onion yield. Among the treatments, Tricho-composts and poultry refuse were the best amendments for *Meloidogyne* spp. reduction and significantly affected onion

growth with the highest yield. Saw dust and rice bran nematicide were also better amendment for root knot nematode decrease which improved plant growth and increased onion yield. These results suggest that soil amendments exploitation in nematode management would be a useful control measure in onion production in Bangladesh.

The significant reduction in nematode and root gall formation observed in the soil amended may be due to the presence of toxic plant materials in soil amendments which have been raised into the soil during decomposition process. Presumably the nematicidal components are absorbed by the roots with adverse effect on the nematodes feeding habit.

Also, present results showed that treatment with tested soil amendments significantly increased chlorophyll concentration (a, b and total chlorophyll) for treated infected eggplant compared to untreated infected control specially cv. Black long. This could be resulted in increasing eggplant tolerance against *M. javanica* infection which reflected in lower disease severity.

These results are in agreement with Ismail *et al*. (2019) findings, who mentioned that among all treatments, compost of poultry manure, cow dung and sheep dung had raised biochemical indicators such as chlorophyll a, b and total chlorophyll content. On the other hand, organic acids released during the organic materials decomposition is one of many factors contributing to reductions in nematode damage (Stephenson, 1945; Johnston, 1959; Sayer *et al*., 1964; Badra *et al*., 1979 ; McBride *et al*., 2000).

Present study supported this view as tested soil amendments induced peroxidases and polyphenol oxidase activity as well as catalase activity in the treated eggplant cultivars (Laeli2hybrid and Black long) inoculated with *M.javanica* where the cabbage, turnip and raddish seeds powder showed the highest effect for CAT activity. Also, for oxidative enzymes activity the cabbage, turnip and raddish seeds powder and pomegranate peels powder showed the highest effect for PPO and PO activity. This could explain that the organic soil amendments had the ability to raise eggplant resistance and reduce *M. javanica* disease parameters (galls, egg masses, eggs/1g root and Juveniles(J2s/250g soil) on eggplant.

Meanwhile, these results are in agreement with EL-Beltagi *et al*. (2012) findings who indicated that the antioxidant substances content and enzymes activity due to nematode infection and soil amendments application pointed to significant increase of lipid peroxidation and hydrogen peroxide as a nematode infection result. Nematode infection raised slightly phenylalaine ammonia lyase activity but enormous increase was observed in treated plants shoots and roots with organic soil amendments.

Oil-cakes application raised the defense enzymes activity (peroxides (PO), polyphenol oxidase (PPO), phenylalanine ammonia lyase (PAL) and superoxide dismutase (SOD) with the time exposure of tomato roots compared to infested check with *M.incognita* (Chandrawat *et al*. 2020).

In conclusion, this study findings revealed that the mixture of cabbage, turnip and raddish seeds powder had strong nematicidal effect and its addition to the soil, controlled the *Meloidogyne javanica* population and resulted in reduction of galls, egg masses, eggs|1g roots and juveniles (J2s)|250g soil numbers and eggplant better growth. Further studies are needed for the application of soil amendments mainly a mixture of cabbage, turnip and raddish seeds powder against *M.javanica* under field conditions.

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فاعلية بعض محسنات التربة العضوية علي نيماتودا تعقد الجذور *Meloidogyne javanica* التى تصيب الباذنجان

الشافعى ابراهيم على الشافعى [1]، محمد احمد محمد الشيخ [2] ، ايمن احمد حسين طلب خطيب [2] و هشام محمد السيد هيكل [2]

[1] قسم النبات الزراعى، كلية الزراعة، جامعة كفر الشيخ

[2] قسم أمراض النبات ، كلية الزراعة، جامعة دمنهور

الملخص

فى تجارب اصص لوحظ ان المعاملة بمحسنات التربة العضوية : مسحوق بذور الكرنب، اللفت و الفجل ، مسحوق قشر الرمان، مسحوق الزنجبيل و زرق الحمام) (30 جرام / اصيص) خفض بشكل معنوى عدد العقد للجذر، عدد كتل البيض للجذر، عدد البيض لكل 1 جرام جذر و عدد اليرقات لكل 250 جرام تربة على جذور نباتات الباذنجان صنفى (هجين لالى2، الطويل الاسود) وذلك 70 يوم من المعاملة و بعد اسبوع من العدوى بنيماتودا تعقد الجذور *Meloidogyne javanica* وكان زرق الحمام الاكثر فاعلية فى خفض كل القياسات المرضية. كما لوحظ تحسن النمو الخضرى و الجذرى للنباتات المصابة و المعاملة بمحسنات التربة العضوية مقارنة بالنباتات المصابة و غير المعاملة ووجد ايضا ان هناك زيادة فى نشاط انزيمات الكتاليز، البولى فينول اوكسديز و البيرواوكسديز فى اوراق النباتات المعاملة بمحسنات التربة العضوية مقارنة بالنباتات المعداه و للغير معاملة. وكذلك ايضا تركيز الاوراق من كلوروفيل ب و الكلورفيل الكلى كان عالى فى حالة المعاملات بمحسنات التربة (مسحوق بذور (الكرنب، اللفت و الفجل)، مسحوق قشر الرمان، مسحوق الزنجبيل و زرق الحمام) مقارنة بالنباتات المصابة والغير معاملة (الكنترول) وذلك مع صنف الباذنجان الطويل الاسود.