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Research Article

The effect of poultry and pigeon manures on pinto bean infection with the root–knot nematode *Meloidogyne javanica*

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Abstract

The pinto bean with a considerable amount of protein plays a key role in human life. Plant parasitic nematodes are known to attack pinto bean plants worldwide. Root-knot nematodes (*Meloidogyne* species) causes extensive damage to legume fields annually. The use of chemical fertilizers leads to instability in agricultural systems and endangers human health. The use of organic fertilizers can be a suitable alternative. The present study examined the effects of different concentrations of pigeon and poultry manures on *M. javanica*-infected pinto bean under greenhouse conditions. Poultry and pigeon manures were individually mixed with steam-sterilized soil at three different concentrations [1, 2, and 3% (w/w)] and the soil was poured into the 1.5 kg plastic pot. Pinto bean seeds were sown in pots and the seedlings were watered until the end of the test and fertilized as needed. Seedlings at the four-leaf stage were inoculated with 4000 eggs of *M. javanica*. The plants were harvested after 60 days and plant growth indices and nematode population indices were determined. The experiment was conducted in completely randomized design tests with five repetitions. The results showed that application of 2% poultry manure was the best treatment that increased shoot length, fresh and dry shoot weight, and fresh root weight in nematode-infected plants. In addition, this amount of poultry manure resulted in a reduction in the number of galls, egg mass and eggs in the root system, the number of second stage juveniles in the soil and the reproductive factor compared to the untreated inoculated control. The results of this study showed that under greenhouse conditions, the effect of poultry manure in reducing nematode damage to pinto beans was greater than that of pigeon manure.

Keywords: Egg mass, Number of galls, Reproductive factor

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مقاله پژوهشی

تاثیر کودهای مرغی و کبوتر بر آلودگی لوبیا چیتی به نماتد غده ریشه *Meloidogyne javanica*

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حیدری، ف.، چاره‌گانی، ح.، عبداللهی، م.، و ادهمی، ا. (۱۴۰۲). تاثیر کودهای مرغی و کبوتر بر آلودگی لوبیا چیتی به نماتد غده ریشه *Meloidogyne javanica*. *دانش بیماری‌شناسی گیاهی، ۱۳ (۱)*، ۱۳-۱.

چکیده

لوبیاچیتی با داشتن مقدار قابل توجهی پروتیین سهم مهمی در زندگی بشر دارد. نماتدهای غده ریشه (گونه‌های *Meloidogyne*) سالانه خسارت زیادی به مزرعه‌های حبوبات وارد می‌کنند. استفاده از کودهای شیمیایی منجر به عدم پایداری سیستم‌های زراعی و به خطر افتادن سلامت بشر شده است و استفاده از کودهای دامی می‌تواند جایگزین مناسبی برای آن باشد. تأثیر نسبت‌های مختلف کودهای کبوتری و مرغی بر گیاه لوبیا چیتی آلوده به نماتد *M. javanica* در شرایط گلخانه در پژوهش حاضر بررسی گردید. بدین منظور کود مرغی و کبوتری پوسیده شده به صورت جداگانه در سه نسبت وزن به وزن ۱، ۲ و ۳ درصد در گلدان‌های ۱/۵ کیلوگرمی با خاک سترون مخلوط شد. بذور لوبیا چیتی در گلدان‌ها کشت و گیاهچه‌ها تا زمان پایان آزمایش در زمان مورد نیاز آبیاری و کوددهی شدند. گیاهچه‌ها در مرحله چهار برگی با ۴۰۰۰ تخم نماتد *M. javanica* مایه‌زنی شدند. گیاهان بعد از گذشت ۶۰ روز برداشت و شاخص‌های رویشی گیاه و جمعیتی نماتد مورد ارزیابی قرار گرفت. آزمایش به صورت فاکتوریل، در قالب طرح کاملاً تصادفی در پنج تکرار انجام گرفت. نتایج نشان داد که استفاده از کود مرغی با نسبت ۲ ٪ وزن به وزن به عنوان بهترین تیمار آزمایش، باعث افزایش طول، وزن تر و خشک شاخساره و وزن تر ریشه در گیاهان آلوده به نماتد *M. javanica* و همچنین باعث کاهش تعداد گال، کیسه تخم و تعداد تخم در سیستم ریشه، تعداد لارو سن دوم در خاک و فاکتور تولیدمثلی نسبت به گیاهان آلوده شاهد (بدون تیمار با کود) شد. یافته‌های این پژوهش نشان داد که استفاده از کود مرغی در مقایسه با کود کبوتر تأثیر بهتری بر کاهش خسارت نماتد *M. javanica* در گیاه لوبیا چیتی دارد.

کلید واژگان: توده تخم، تعداد گال‌ها، فاکتور تولیدمثلی

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Introduction مقدمه

Legumes are the second most important source of human nutrition, after cereals (Broughton et al. 2003). One of the unique properties of legumes is the formation of nodules on their roots. Inside the nodules, the bacteria convert free nitrogen into ammonia, which the host plant uses for its development (Wagner 2011). Nitrogen bound by the bean root can cover up to 70% of the plants' nitrogen needs (Ma et al. 2022). Among plant pathogens, plant parasitic nematodes cause severe damage and yield loss worldwide, estimated to cause losses of more than $80 billion per year (Sikder and Vestergard 2020). The root-knot nematodes (*Meloidogyne* species) has a wide host range and is one of the most damaging groups of plant parasitic nematodes (Sasser and Carter 1985). In modern agriculture, the use of chemical nematicides is one of the main methods of controlling plant pathogenic nematodes (Taylor 2003). Widespread use of nematicides leaves large toxic residues in the environment, particularly on non-target organisms (Anastasia et al., 2008). In recent years, biological control, the use of resistant varieties, crop rotation, the use of trap plants and the use of plant and animal organic materials have been proven to be safe management methods for controlling plant parasitic nematodes (Abd-Elgawad 2021). Livestock manure has been shown to increase crop production (Rayne and Aula 2020). Organic fertilizers are an important source of nutrition for plants and a source of energy for soil microorganisms. Organic matter increases the activity of parasitic nematode antagonists and decomposes soil organic matter, leading to the accumulation of anti-nematode compounds in the soil (Akhtar and Malik 2000).

Poultry manure is a type of livestock manure and a source of organic matter to improve soil conditions. Compared to conventional fertilizers, it is one of the cheapest fertilizers. The nitrogen content of poultry manure is higher than other livestock manure (Hirzell and Walter 2008). In addition to the various nutrients, chicken manure has properties such as the gradual release of nitrogen (helps to reduce leaching of nitrates), potassium and calcium (helps to reduce soil acidity), and due to its high organic matter content, it has the capacity of water storage and increasing nutrition (Pelletier et al. 2001). Adding 2% garlic residue and rabbit manure to the soil and covering with plastic before planting resulted in a 72.6% increase in tomato yield and a 72.4% reduction in the gall index of *M. incognita* (Gong et al. 2013). Application of poultry manure reduced the population of *M. incognita* in cacao plants (Orisajo et al. 2008). The use of organic fertilizers, including poultry manure in Gabon, has proven to be very effective in controlling root nematodes on tomato plants (Poswal and Faull 1989). Renco et al. (2007) observed the inverse relationship between poultry manure use and reproductive factor of *Globodera rostochiensis*. Application of poultry, goat and cow manure reduced the population of *M. javanica* by 52.58, 49.02 and 46.06%, respectively (Karmani et al. 2011). The use of unsterilized poultry manure has greatly reduced *M. arenaria* infection of tomatoes. The antagonistic bacteria contained in these fertilizers reduced the activity of juvenile nematodes (J2s) and thus their mortality. (Kaplan et al. 1992). Using poultry manure to control root knot nematodes reduced nematode populations by 24% (Nico et al. 2004). In some cases, the use of animal fertilizers has been found to cause phytotoxicity. Therefore, the present study aimed to find the appropriate concentration of poultry and pigeon manure and compare them to reduce the damage of *M. javanica* in pinto beans and cause less damage to the plant.

Materials and Methods مواد و روش‌ها

Preparation of fertilizers

Poultry manure from chicken coops and pigeon manure from indoor nests were collected around the city of Safashahr in Fars Province, Iran, in 2019. They were kept in the shade for two months.

Plant growing medium

The plant growth medium consisted of sandy loam soil and sand (1:3). At the time of transplanting, poultry and pigeon manure were added to the Soil mixture in three rates of 1, 2 and 3% (w/w). Soil physicochemical properties were measured as follows: soil texture using a soil texture hydrometer (Bouyoucos 1962); electrical conductivity (Rhoades 1996) using a Jenway Mark model 4310 conductivity meter; available soil phosphorus with the Olsen method (Olsen et al. 1954) with Lambda EZ 201 spectrophotometer, soil pH with pH meter, potassium with Jenway Mark flame photometer pfp7 device, DTPA extractable zinc, copper and manganese with Hibachi ZCAST2300 atomic absorption spectrometer (Lindsay and Norvell 1978); Calcium carbonate equivalent according to the method of Richards (1947) and organic matter according to the method of Jackson (1975). One gram of the ground pigeon and poultry droppings was extracted by the dry ashing method (Rowell 1993). In the extracts, phosphorus was measured with the yellow colorimetric method using ammonium vanadate, potassium reagent with a Jenway Mark flame photometer and model pfp7, microelements including zinc and copper were measured with a Hibachi Mark atomic absorption device, and pH was measured with a pH -Value measured by Hanna pH 213 measuring device.

Nematode inoculum

The roots of nematode-infected tomatoes were collected from greenhouses in Kohgiluyeh and Boyer-Ahmad province in Iran. The samples were carefully washed under gentle water flow. One gall containing an egg mass was collected and cultivated on tomato seedlings (variety Early-Urbana) in the greenhouse. After 60 days, plants were harvested and root nematode species were identified based on the morphological characteristics of the female perennial pattern and J2s, as described by Jepson 1987.

Greenhouse studies

Pinto bean (*Phaseolus vulgaris* L.) seeds were sown in plastic pots containing 1.5 kg of the growth medium and placed under greenhouse conditions at 27 ± 5 °C and 65% relative humidity for 16 h in light and 8 h in dark. After 30 days, three holes with a depth of one centimeter were made in the growth medium around the roots and 1 ml of nematode egg suspension (4000 eggs/ml) was added to the holes and the holes were immediately covered with soil. Plant growth medium without poultry or pigeon manure was used as a negative control. The experiment was conducted in a completely randomized design with five replications. Two months after inoculation, the plants were harvested and the shoot length, fresh and dry shoot weight and fresh root weight were measured. The roots were carefully washed with a gentle stream of water. The root surface water was removed with a paper towel. The roots were then cut into approximately 1 to 2 cm segments using scissors. One gram of the nematode-inoculated root was used to extract eggs with 0.5% sodium hypochlorite solution. The collected eggs were counted and calculated for the total root volume (Hussey and Baker 1973). One gram of nematode-inoculated root was stained using acid fuchsin 0.1% solution according to Byrd et al. (1983) and number of galls and egg masses were counted and then the numbers were calculated for total root volume. The number of J2 per 100 grams of soil was counted using the tray method of Whitehead and Hemming (1965) and generalized to the total soil volume. The final nematode population density was calculated by summing the number of nematodes in roots and soil. The nematode reproductive factor (RF) was calculated according to Taylor and Sasser (1978) by dividing the final nematode population into the initial nematode population density.

To measure the elements such as potassium, phosphorus, zinc, copper and manganese in the aerial part of the plant, the dried leaves were ground and one gram was extracted through dry digestion (Rowell 1993).

Statistical analysis

Data were subjected to a factorial analysis of variance (FANOVA) for plant growth parameters as well as the elements measurement, and one-way analysis of variance (ANOVA) for nematode population indices using SAS statistical software (ver. 9.4) (SAS Institute, Cary, NC). Where the interaction was significant at $P < 0.05$, it was used to explain results. Treatment means were compared with the Tukey-Kramer HSD.

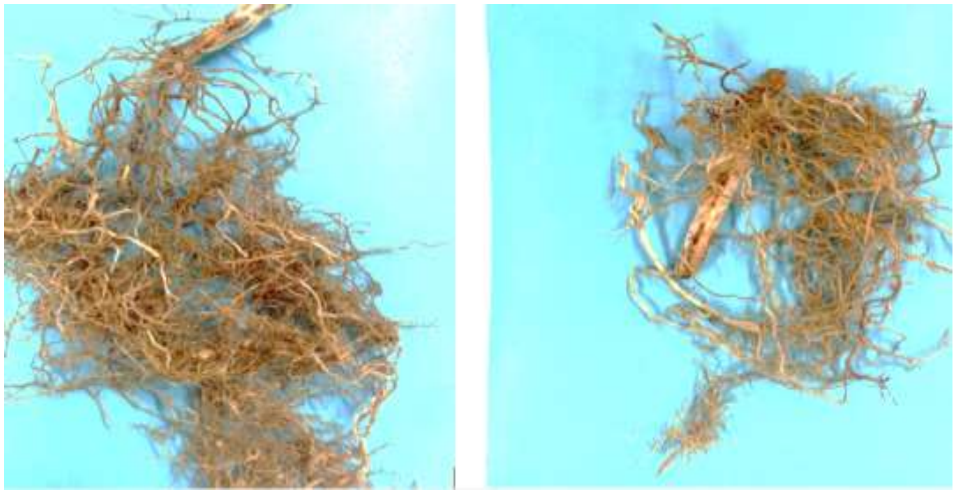
Results یافته‌ها

Chemical properties of fertilizer and soil

Pigeon droppings with a pH of 6.84 contained 8.50 g/kg phosphorus, 5.56 g/kg potassium, 10.6 mg/kg zinc, 1.85 mg/kg copper, 8.87 mg/kg manganese and poultry manure with a pH of 7.37 contained 6.80 g/kg phosphorus, 3.50 g/kg potassium, 4.90 mg/kg zinc, 0.21 mg/kg copper and 4.85 mg/kg Manganese. Plant growth medium with electrical conductivity (EC) = 0.671 dS m-1, pH = 7.45, contains 76% calcium carbonate, 52.9 mg/kg phosphorus, 0.170 mg/kg organic matter and 0.0987 mg/kg organic carbon.

Vegetative indices of plants

The highest shoot length was observed in un-inoculated plants treated with 2% wt. poultry manure. There was no significant difference in un-inoculated plants treated with 1 and 3% (w/w) poultry manure, in un-inoculated plants treated with 1% (w/w) pigeon manure, and inoculated ones Plants treated with 2% (w/w) poultry manure (P < 0.05). The highest fresh shoot weight was observed in nematode un-inoculated plants treated with 2% w/w poultry manure which had a significant difference with treated and control plants ($P < 0.05$). The lowest dry shoot weight was observed in the nematode inoculated control plants (Fig. 1). It had no significant difference only with nematode inoculated plants and treated with 3% w/w pigeon manure ($P < 0.05$). In each treatment, fresh root weight in nematode inoculated and un-inoculated plants were not significantly different (Table 1).



شکل ۱. ریشه‌های لوبیا آلوده به *Meloidogyne javanica* و تیمار شده با کود مرغی به میزان ۲ ٪ (چپ)، بوته شاهد تیمار نشده و آلوده به نماتد (راست)

Figure 1. The roots of pinto bean inoculated with *Meloidogyne javanica* and treated with 2% poultry manure (left), Untreated nematode inoculated control plant (right).

جدول ۱. میانگین شاخص‌های رویشی لوبیا آلوده به *Meloidogyne javanica* و تیمار شده با غلظت‌های مختلف کودهای مرغی و کبوتر.

Table 1. Mean plant growth indices of pinto bean infected with *Meloidogyne javanica* treated with different ratios of pigeon and poultry manures.

Treatments	Nematode inoculation	Shoot Length (cm)	Fresh shoot weight (g)	Dry shoot weight (g)	Fresh root weight (g)
Control	Un-inoculated	83.6 def	9.93 f	1.52 cde	4.55 e-g
	Inoculated	51.3 g	5.53 h	0.88 f	5.05 d-f
Pigeon 1% (w/w)	Un-inoculated	113 ab	13.6 bcd	1.95 a	6.15 a-c
	Inoculated	90.27 cde	11.26 def	1.8 abc	6.15 ab
Pigeon 2% (w/w)	Un-inoculated	75.75 ef	10.28 f	1.8 abc	4.54 e-g
	Inoculated	71.27 f	8.71 fg	1.37 de	5.11 c-f
Pigeon 3% (w/w)	Un-inoculated	78.75 ef	10.95 ef	1.64 a-d	4.02 g
	Inoculated	68.22 f	6.92 gh	1.01 f	4.86 d-g
Poultry 1% (w/w)	Un-inoculated	104 abc	16 b	1.62 bcd	5.12 c-f
	Inoculated	86.5 def	14.81 bc	1.51 cde	5.19 b-e
Poultry 2% (w/w)	Un-inoculated	119 a	18.39 a	1.9 ab	6.25 a
	Inoculated	105 abc	15.79 b	1.64 a-d	5.71 a-d
Poultry 3% (w/w)	Un-inoculated	107 abc	12.93 cde	1.74 abc	4.34 e-g
	Inoculated	100 bcd	10.75 ef	1.29 e	4.11 fg

Values in the same column followed by different letter(s) are significantly different according to Tukey-Kramer HSD ($P < 0.05$). Each treatment had five replications.

Nematode population indices

The lowest number of galls in root system were observed in treated plants with 1% w/w pigeon manure. It had no significant difference with 2 and 3% w/w poultry-treated plants ($P < 0.05$). The lowest number of egg masses in the root system were observed in treated plants with 1% w/w pigeon manure. It had no significant difference with 2% w/w pigeon and poultry-treated plants as well as 3% w/w pigeon-treated plants ($P < 0.05$). The lowest number of J2s in the soil were observed in treated plants with 2% and 3% w/w poultry manure which had a significant difference with other treatments ($P < 0.05$). The lowest number of eggs in the root system were observed in plants treated with 1% w/w pigeon manure which had a significant difference with control plants ($P < 0.05$). The lowest reproduction factor was observed in treated plants with 2% w/w poultry manure. It had significant difference with 1% w/w pigeon and poultry-treated plants as well as control plants. The number of galls in the root system, number of egg masses in the root system, number of J2s in the soil and the reproduction factor in control plants were significantly higher than treated plants ($P < 0.05$). The highest number of eggs in root system were observed in control plants (Table 2). It had non-significant difference with 2 and 3% w/w pigeon -treated plants ($P < 0.05$).

Content of elements in plants

The lowest phosphorus content was observed in the uninoculated control plants. It had significant difference with uninoculated and treated plants with 2 and 3% w/w pigeon manure as well as inoculated and treated plants with 3% w/w poultry manure ($P < 0.05$). In each treatment, phosphorus content in the inoculated and uninoculated plants were not significantly different ($P < 0.05$). The highest potassium content was observed in the inoculated plants treated with 3% w/w poultry manure. It had significant difference with uninoculated and inoculated plants treated with 3% w/w pigeon manure as well as uninoculated plants treated with 2% w/w pigeon manure ($P < 0.05$). The content of

جدول ۲. میانگین شاخص‌های جمعیتی نماتد *Meloidogyne javanica* در لوبیا تیمار شده با غلظت‌های مختلف کودهای مرغی و کبوتر.

Table 2. Average population indices of *Meloidogyne javanica* in pinto bean plants treated with different ratios of pigeon and poultry manures*.

Treatments	Number of eggs/ root system	Number of galls/ root system	Number of egg masses/ root system	Number of J2s/ pot	Reproduction factor
Control	12797 a	426 a	373 a	3685 a	4.21 a
Pigeon 1% (w/w)	10697 b	165 e	160 c	2992 b	3.46 b
Pigeon 2% (w/w)	11351 ab	231 cd	204 bc	614 c	3.04 bc
Pigeon 3% (w/w)	11665 ab	308 b	202 bc	610 c	3.12 bc
Poultry 1% (w/w)	11150 b	279 bc	242 b	2257 b	3.41 b
Poultry 2% (w/w)	10710 b	192 de	173 c	304 d	2.8 c
Poultry 3% (w/w)	10860 b	225 cde	197 b	373 d	2.86 c

*Values in the same column followed by different letter(s) are significantly different according to Tukey-Kramer HSD ($P < 0.05$). Each treatment had five replications.

جدول ۳. میانگین مقدار عناصر در برگ گیاهان لوبیا سالم و آلوده به *Meloidogyne javanica* و تیمار شده با غلظت‌های مختلف کودهای مرغی و کبوتر.

Table 3. Average content of elements in leaves of uninoculated and inoculated pinto bean plants with *Meloidogyne javanica* and treated with different concentrations of pigeon and poultry manures

Treatments	Nematode	Phosphor (Mg/kg)	Potassium (Mg/kg)	Magnesium (Mg/kg)	Copper (Mg/kg)	Zinc (Mg/kg)
Control	Un-inoculated	1577 b	19452 ab	32.18 a	4.08 de	26.82 bc
	Inoculated	1777 ab	17741 abc	39.24 a	2.88 de	38.13 ab
Pigeon 1% (w/w)	Un-inoculated	3156 ab	18137 abc	33 a	5.12 cde	27 bc
	Inoculated	2670 ab	18747 ab	44 a	2.5 e	39.5 ab
Pigeon 2% (w/w)	Un-inoculated	3437 a	12326 c	32.83 a	9 abc	29.33 abc
	Inoculated	2583 ab	17413 abc	43.45 a	11 a	42.16 a
Pigeon 3% (w/w)	Un-inoculated	3330 a	13884 bc	42 a	5 cde	28.5 bc
	Inoculated	1783 ab	13601 bc	40.16 a	5.83 b-e	24.29 c
Poultry 1% (w/w)	Un-inoculated	2745 ab	17688 abc	33.4 a	3.54 de	29.92 abc
	Inoculated	2916 ab	18813ab	38.12 a	4 de	29.87 abc
Poultry 2% (w/w)	Un-inoculated	2911 ab	19912ab	41.3 a	10.1 ab	36.3 abc
	Inoculated	3020 ab	20816 a	38.11 a	6.52 b-e	38.63 ab
Poultry 3% (w/w)	Un-inoculated	2321 ab	19639 ab	42.93 a	4.23 de	32.4 abc
	Inoculated	3452 a	22916 a	36.22 a	7.06 a-d	35.05 abc

Values in the same column followed by different letter(s) are significantly different according to Tukey-Kramer HSD ($P < 0.05$). Each treatment had five replications.

manganese in all treatments had no significant difference ($P < 0.05$). In each treatment, the content of copper and zinc in nematode inoculated and uninoculated plants were not significantly different (Table 3).

Discussion بحث

In the present study, we examined the effects of different concentrations of pigeon and poultry manure on infected pinto bean with *M. javanica* under greenhouse conditions. Addition of any organic matter decomposable in soil is one of the ways that can lead to changes in physicochemical and biological conditions of soil and providing favorable conditions for antagonists in order to establish biological control of soil-borne plant pathogens (Westphal et al. 2016). The chemical composition of the organic fertilizers varies depending on the type and the age of animal. It has been reported by various researchers that adding any type of organic amendments to the soil enhanced the population of the bacterivores and fungi ores nematodes (Fourie et al. 2016; Renco et al. 2011). Addition of organic amendments to soil has a significant impact on the diversity and population of nematodes (Bulluck et al. 2002).

Our results showed that application of 2% poultry manure reduced number of eggs of *M. javanica* by about 16%, compared to the inoculated control plants. A mixture of fresh olive pomace, straw, poultry manure and urea on potato crop reduced number of eggs of *G. rostochiensis* by about 80% (Renco et al. 2007). Different plant parasitic nematodes as well as other compounds in the mixture which had used by Renco et al. (2007) are the reason of more reduction in the number of eggs of *G. rostochiensis* than number of eggs of *M. javanica* in the present study. The number of *M. incognita* and other plant parasitic nematodes in soil were significantly minified after treatments of grapevine with chicken, sheep and cow manure (El-Ashry 2021). The results of another study showed that application of cow, horse and turkey manures significantly minified numbers of plant parasitic nematodes in a mandarin orchard (El-Marzoky et al. 2018). Poultry manure reduces population of *Pratylenchus, Hoplolaimus* and *M. incognita* in sugar beet plants (Mahran et al. 2008). These results were in agreement with the results of present study. We showed that application of 2% poultry manure reduced number of J2s in soil by 92%. A research indicated an inverse relationship between different concentrations of pigeon manure and the reproduction factor of *M. are aria* in tomato roots (Kaplan and Noe 1995). These results were in agreement with the results of present study. We showed that application of 1% pigeon manure reduced the reproduction factor of nematode by 18% while with the increase in the concentration of pigeon manure (2% w/w) the reproduction factor of nematode reduced by 28%, compared to the inoculated control plants. As a matter of fact, organic compounds, such as poultry manures, have an immediate effect on reducing the population of nematodes in soils, as the result of dispersion of ammonia which started immediately after the microbial degradation. Reducing the C/N ratio has an effective role in the reduction of nematode population, which is directly related to physical and chemical properties of soil. The degradation of organic materials produces nematicidal compositions such as organic acids, nitrogen compositions and secondary metabolites which lead to nematode population reduction (Lazaro its et al. 2001). Increasing the proteolytic enzymes and chitinase in the soil, which eliminates the cuticle layer of J2s and the nematode eggs layer (Stirling 2014) is another mechanism which lead to nematode population reduction.

Khan et al. (2001) stated that yield of infected chilli with *Meloidogyne* spp. was remarkably increased by pigeon and poultry manure compared to control plants. Root-knot nematode damage on Groundnut (Jioshi and Patel, 1995), banana (Sundararaju et al. 2002) and cacao plants (Orisajo et al. 2008) was decreased by application of poultry manure. These results were in agreement with the results of present study. The results of our studies showed that application of 2% poultry manure increased the shoot length, fresh shoot weight and dry shoot weight by 51, 65 and 46%, respectively, compared to the inoculated control plants. Also damage of *M. javanica* on tomato (Maarge et al. 2000) was decreased by application of pigeon manure. These results were in agreement with the results of present study. The results of our studies showed that application of 1% pigeon manure increased the shoot length, fresh shoot weight and dry shoot weight by 43, 50 and 51%, respectively, compared to the inoculated control plants. As a matter of fact, by adding organic matter to the soil, especially poultry manure, the population of free-living nematodes has increased, indicating improvement of soil physico-chemical conditions which is useful for them as well as to stimulate the plant growth (Stirling 2014).

One study found that organic fertilizer application increased soil nutrients and therefore microbial activity, whereas poultry manure with higher nutrients compared to other treatments increased the microbial population and soil organic matter degradation rate, thus increasing substrate utilization for soil microorganisms at the rate of C-CO2 -Removal from the ground (Ouedraogo et al. 2007). Poultry manure produces toxic compounds, including ammonia gas, nitrates, sulfur gas and organic acids which have been directly toxic to the nematodes and indirectly affected the egg hatching and the mortality rate of J2s (Brzeski and Dow 1969). Livestock manures act as a double-edged sword, in optimal concentration, they improve plant growth indices and reduce nematode population indices, and in higher concentrations, they cause damage to the plants and decrease beneficial soil microorganisms. Therefore, in the present study, different concentrations of poultry and pigeon manures were used to find the appropriate concentration of them.

Conclusion نتیجه‌گیری

The use of poultry and pigeon manure significantly reduced the nematode indices in the infected pinto bean plants compared to the control. The highest plant growth indices and the lowest number of eggs and galls per root system were observed in plants treated with poultry manure at a rate of 2% w/w, indicating that poultry manure had a better effect on nematode-infected pinto bean plants in the greenhouse as pigeon droppings conditions.

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References منابع

1. Abd-Elgawad, M.M.M. (2021). Optimizing safe approaches to manage plant-parasitic nematodes. *Plants*, 10(9), 1911.
2. Akhtar, M. & Malik, A. (2000). Roles of organic soil amendments and soil organisms in the biological control of plant- parasitic nematodes: a review. *Bio. resource Technol.*, 74(1), 35-47.
3. Anastasiadis, I.A., Giannakou, I.O., Prophetou-Athanasiadou, D.A. & Gowen, S.R. (2008). The combined effect of the application of a biocontrol agent *Paecilomyces lilacinus*, with various practices for the control of root-knot nematodes. *Crop Prot.,* 27, 352-361.
4. Bouyoucos, G.J. (1962). Hydrometer method improved for making particle size analyses of soils. *Agron J*, 54, 464-465.
5. Broughton, W.J., Hernandez, G., Blair, M., Beebe, S., Gepts, P. & Vanderleyden, J. (2003). Beans (*Phaseolus* spp.)- model food legumes. *Plant Soil*, 252, 55-128.
6. Brzeski, M.W. & Dowe, A. (1969). Effect of pH on *Tylenchorhynchus dubius* (Nematoda, Tylenchidae). *Nematologica,* 15, 403-407.
7. Bulluck, L.R., Barker, K.R. & Ristaino, J.B. (2002). Influences of organic and synthetic soil fertility amendments on nematode trophic groups and community dynamics under tomatoes. *Appl. Soil Ecol.*, 21 (3), 233-250.

8. Byrd, D.W., Kirkpatrick, T. & Barker, K.R. (1983). An improved technique for clearing and staining plant tissues for detection of nematodes. *J. Nematol.,* 15(1), 142-143.

9. El-Ashry, R.M. (2021). Application of animal manure and plant growth- promoting rhizobacteria as effective tools to control soil nematode population and increase crop yield in grapevine orchards. *Egypt. J. Agronematol.,* 20, 34-52.

10. El-Marzoky, A.M., Eldeeb, A.M., Mahrous, M.E. & El-Ashry, R.M. (2018). Influence of certain animal manures on nematode community in mandarin orchards citrus reticulata (Blanco) in Sharkia Governorate, Egypt. *Egypt. J. Agronematol.,* 17, 143-156.

11. Fourie, H., Ahuja, P., Lammers, J. & Daneel, M. (2016). Brassicacea-based management strategies as an alternative to combat nematode pests: A synopsis review article. *Crop Protect.,* 80, 21-41.

12. Gong, B., Bloszies, S., Li, X., Wei, M., Yang, F., Shi, Q. & Wang, X. (2013). Efficacy of garlic straw application against root-knot nematodes (*Meloidogyne incognita*) on tomato. *Sci. Hortic.,* 161, 49 -57.

13. Hirzell, J. & Walter, I. (2008). Availability of nitrogen, phosphorus and potassium from poultry litter and conventional fertilizers in a volcanic soil cultivated with silage corn. *Chil. J. Agric. Res.,* 68, 264-273.

14. Hussey, R.S. & Barker, K.R. (1973). Comparison of methods of collecting inoculate of *Meloidogyne* spp. including a new technique. *Plant Dis. Rep.,* 57, 1025-1028.

15. Jackson, M.L. (1975). *Soil chemical analysis: Advanced course*. (11^{nd} ed.). University of Wisconsin-Madison Library, WI, USA.

16. Jepson, S.B. (1987). *Identification of root-knot nematodes* Meloidogyne *species.* CABI Wallingford.

17. Jioshi, P.R. & Patel, H.R. (1995). Organic amendments in management of *Meloidogyne javanica* on groundnut. *Indian J. of Nematol.,* 25, 76-78.

18. Kaplan, M. & Noe, J.P. (1995). Effects of chicken excrement amendments on *Meloidogyne arenaria*. *J. Nematol.,* 25 (1), 71-77.

19. Kaplan, M., Noe, J.P. & Hartel, P.G. (1992). The role of microbes associated with chicken litter in the suppression of *Meloidogyne arenaria*. *J. Nematol.,* 24, 522-527.

20. Karmani, B.K., Jiskani, M.M., Khaskheli, M.I. & Wagan, K.H. (2011). Influence of organic amendments on population and reproduction of root-knot nematode, *Meloidogyne incognita* in eggplants. *Pak. J. Agric. Agric. Eng. Vet. Sci.,* 27(2), 150-159.

21. Khan, A., Shaukat, S.S., Qamar, F., Islam, S., Hakro, A.A. & Jaffry, A.F. (2001). Management of plant parasitic nematodes associated with chilli through organic soil amendments. *Pak. J. Biol. Sci.,* 4, 417-418.

22. Lazarovits, G., Tenuta, M. & Conn, K.L. (2001). Organic amendments as a disease control strategy for soil borne disease of high-value agricultural crops. *Australas. Plant. Pathol.,* 30, 11- 22.

23. Lindsay, W.L. & Norvell, W.A. (1978). Development of a DTPA soil test for zinc, iron, manganese and copper. *All Crop, Soil, Env. Sci. Soc.*, 42, 421-428.

24. Ma, J., Olin, S., Anthoni, P., Rabin, S.S., Bayer, A.D., Nyawira, S.S. & Arneth, A. (2022). Modeling symbiotic biological nitrogen fixation in grain legumes globally with LPJ-GUESS (v4.0, r10285). *Geosci. Model. Dev.*, 15, 815–839.

25. Maareg, M.F., Salem, F.M. & Ebieda, E.M. (2000). Effect of certain organic and inorganic amendments on *Meloidogyne javanica* in sandy soil. *Egypt. J. Agronematol.*, 4, 82-94.

26. Mahran, A., Conn, K.L., Tenuta, M., Lazarovits, G. & Daayf, F. (2008). Effectiveness of liquid hog manure and acidification to kill *Pratylenchus* spp. in soil. *J. Nematol.*, 40, 266-275.

27. Nico, A.I., Jimenez-Diaz, R.M. & Castilla, P. (2004). Control of root-knot nematodes by composed agro-industrial wastes in potting mixtures. *Crop Protect.,* 23, 581-587.

28. Olsen, S.R., Cole, C.V., Watanabe, F.S. & Dean, L.A. (1954). Estimation of available phosphorus in soils by extraction with sodium bicarbonate. *Circular,* 939, 19.

29. Orisajo, S.B., Afolami, S.O., Fademi, O. & Atungwu, J.J. (2008). Effects of poultry litter and carbofuran soil amendments on *Meloidogyne incognita* attacks on cacao. *J. Appl. Biosci.*, 7, 214-221.

30. Ouedraogo, E., Mando, A., Brussaard, L. & Stroosnijder, L. (2007). Tillage and fertility management effects on soil organic matter and sorghum yield in semiarid West Africa. *Soil Tillage Res.*, 94, 64-74.

31. Pelletier, B.A., Pease, J. & Kenyon, D. (2001). *Economic analysis of Virginia poultry litter transportation.* Virginia Agricultural Experiment Station, Bulletin. Blacksburg, Virginia, USA

32. Poswal, K.A. & Faull, J.L. (1989). Commercial approaches to the use of biological control agents. In: J.M. Whipps, R.D. Lumsden (Eds.), *Biotechnology of fungi for improving plant growth.* (pp 75-259). Cambridge University Press, Cambridge, UK.

33. Rayne, N. & Aula, L. (2020). Livestock manure and the impacts on soil health: A review. *Soil Syst*., 4, 64.

34. Renco, M., Daddabbo, T., Sasanelli, N. & Papajova, I. (2007). The effect of five composts of different origin on the survival and reproduction of *Globodera rostochiensis*. *Nematology,* 9, 537-543.

35. Renco, M., Sasanelli, N., D′Addabbo, T. & Papajová, I. (2011). Soil nematode community changes associated with compost amendments. *Nematology,* 12, 681-692.

36. Rhoades, J.D. (1996). Salinity: electrical conductivity and total dissolved solids. In: R.L. Sparks (Ed.), *Methods for soil analysis, Part 3: Chemical Methods.* (pp 417-435). Soil Science Society of America, Madison, USA.

37. Richards, L.A. (1947). *Diagnosis and improvement of saline and alkaline soils.* (Handbook No 60). Washington DC, USA. US Salinity Laboratory Staff, USDA.

38. Rowell, D.L. (1993). *Soil science: methods and applications*. Longmans, Harlow, UK.

39. Sasser, J.N. & Carter, C.C. (1985). *An advanced treatise on Meloidogyne, biology and control* (Vol 1). North Carolina State University Graphics.

40. Sikder, M.M. & Vestergard, M. (2020). Impacts of root metabolites on soil nematodes. *Front. Plant. Sci*., 10, 1792.

41. Stirling, G.R. (2014). *Biological control of plant-parasitic nematodes: Soil ecosystem management in sustainable agriculture*. (2nd ed.). CAB International, Melksham, UK.

42. Sundararaju, P., Mustaffa, M.M., Kumar, V., Cannayane, I. & Tanuja Priya, B. (2002). Effect of organic farming on plant-parasitic nematodes infesting banana cv. Karpuravalli. *Curr. Nematol.*, 13, 39-43.

43. Taylor, A.L. (2003). Nematocides and nematicides – a history. *Nematropica*, 33, 225–232.

44. Taylor, A.L. & Sasser, J.N. (1978). *Biology, identification, and control of root-knot nematodes* (Meloidogyne *species*). North Carolina State University Graphics, Raleigh, USA.

45. Wagner, S.C. (2011). Biological Nitrogen Fixation. *Nat. Educ. Knowl*., 3, 15.

46. Westphal, A., Kücke, M. & Heuer, H. (2016). Soil amendment with digestate from bio-energy fermenters for mitigating damage to *Beta vulgaris* subspp. by *Heterodera schachtii*. *Appl. Soil. Ecol.*, 99, 129-136.

47. Whitehead, A.G. & Hemming, J.R. (1965). A comparison of some quantitative methods of extracting small vermiform nematodes from soil. *Ann. Appl. Biol.*, 55, 25-38.