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COMBINATION OF VERMICOMPOSTS AND BIOPESTICIDES AGAINST NEMATODE (PRATYLENCHUS SP.) AND THEIR EFFECT ON GROWTH AND YIELD OF TOMATO (*LYCOPERSICON ESCULENTUM*)

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ABSTRACT

Vermicomposts singly and in combination with different biopesticide were used in agricultural field to check the infestation of nematode (Pratylenchus sp.) and measured the growth and yield of tomato (Lycopersicon esculentum) crop. Significant reduction of nematode population was observed in the soil after mixing of combination of vermicompost with neem oil (95%) and custard apple leaves (83%). The combination of garlic extract with different vermicompost caused 100% control of nematode population. Vermicompost obtained from animal dung + gram bran with neem oil was also very effective against the nematode (Pratylenchus sp.). Applications of vermicompost with biopesticide increased the productivity of tomato crop up to four times with respect to control. The results clearly demonstrate that the use of vermicompost with plant product is more beneficial in organic farming. It is helpful to compensate the deficiency of nutrients in the soil as well as control of the harmful nematode.

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KEY WORDS

Vermicomposting; Eisenia foetida; biopesticide; nematodes; Lycopersicon esculentum; productivity

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[I] INTRODUCTION

Lycopersicon esculentum (Tomato), most popular cultivated fruit vegetable, belongs to family Solanaceae. Commonly it is used as soup, salad, pickles, ketchup, puree and sauses. Its pressed cake is used as fodder for cattle and as fertilizer [1]. Use of chemical fertilizers and synthetic pesticide increase the productivity of the crops, but it also leads to decline the different physico-chemical parameters of soil [2]. The regular cultivation of land without incorporation of organic matter caused deterioration of the soil quality [3]. Management of soil quality, by the use of the bio-products is a need of today. Consequently, more biological wastes are used for production of biofertilizer [4].Vermicomposting is one of them. The vermicomposting is a suitable way of waste management with help of earthworm Eisenia foetida. Organic composts have recognized as effective mean of improving soil fertility [5-7]. Vermicomposts are finally peat like materials with high porosity, aeration, drainage and water holding capacity [8].

The phytoparasitic nematodes damaged the productivity of crops [9]. The plant parasitic nematodes bearing a style which helps the nematodes to punctured the protective wall of host plant. The nematodes inject the secretion of oesophageal gland which dissolved the cell wall of the host plant, ingest the cell content. Ultimately, resulted a poor plant growth, winter injury and wilting of the tree, loss of seedlings [10]. The addition of organic material in soil has been used in managing plant parasitic nematodes, to increase the crop yield [11]. Meyer et al., [12] have reported that clove oil derived from clove plant (Synzygium aromaticum) is effective against various soil born plant parasitic nematodes.

Gupta and Sharma [13] reported that aqueous extract of garlic bulbs suppressed the hatching of Meloidagyne incognita eggs. Plant products are receiving greater attention as prophylactics against several species of plant-parasitic nematodes. Various products (oils, cakes, extracts, etc.) prepared from the leaves and seed of neem plant (Azadirachta indica) have been reported as effective protectants against nematode pests. Akhtar [14] and Akhtar and Mahamood [11] have reported that the utilization of wastes material such as oil seeds, cake, chitin, compost, livestock and poultry manures and cellulogic wastes appeared promising for reducing population of plant parasitic nematodes. They also suggested that nitrogen based amendment, plant phenolics, nematotoxic chemical, development of predators and parasites of nematodes and

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micro-organism stimulation have been considered to be promising agent for nematodes managements.

The aim of the present study is to investigate the effect of vermicompost of different animal (cow, buffalo, sheep, goat and horse) dung and agro / kitchen waste singly as well in binary combination with different biopesticides against the harmful soil nematode (*Pratylenchus* sp.) and their related growth, flowering and productivity of tomato crop.

[II] MATERIALS AND METHODS

2.1. Collection of Wastes

Different kinds of organic wastes which are used for vermicomposting as well as feeding material for earthworms Eisenia foetida, were collected from different parts of Gorakhpur district.

2.1.1. Animal wastes

Animal wastes (cow, buffalo, sheep, horse, goat dung) were collected from different farm houses of the Gorakhpur district.

2.1.2. Agro wastes

Different agro wastes (gram bran, straw, wheat bran, barley bran and rice bran) vegetable wastes were collected from rural and urban parts of Gorakhpur district. Partially decomposed mixtures of animal, agro/kitchen wastes were used for enhancement of vermicomposting efficiency. For this purpose, the mixture of organic wastes sprayed in a layer of 1-2 feet and exposed to sun light for 5 to 10 days to removing the various harmful organism and noxious gases [15].

2.2. Collection of earthworms

Earth worms Eisenia foetida an epigeic species were cultured in laboratory condition, temperature (20 to 30 0C) and aeration, moisture (40% to 60%) for proper growth and survival of earthworms by the method of Gupta [4].

2.3. Preparation of vermicomposts

Vermicomposts of different animal and agro wastes were prepared on cemented earth surface. There are 35 vermibed formed by different combinations of animal, agro / kitchen wastes in 1:1 ratio the size of each vermibed is 3m x 1m x 9cm. After formation of vermibed moist it and inoculated 2kg cultured Eisenia foetida in each bed. The beds were covered with jute pockets and moisten the bed daily up to 40 to 50 days for maintaining the moisture content. After one week interval, mixture of bed was manually turned up to 3 weeks. After 50 to 60 days granular tea like vermicompost appear on the upper surface of beds.

2.4. Collection and preparation of biopesticide

2.4.1. Neem oil

Neem oil obtained from neem seed (Azadirachta indica). Neem Oil-Azadirachtine, 00.03 %; neem oil, 90.57%; Hydroxy El, 05.00% ; Epichlorohydrine 00.50 %; Aromax, 03.9%; Multiplex agricare Pvt. Ltd.

2.4.2. Garlic extract

Aqueous extract of Garlic (10gm/100ml) obtained from garlic (Allium sativum) bulb was mixed with vermicompost in 1:100 ratio.

2.4.3. Custard apple

Leaves are collected from plant of Custard apple (Annona squamosa). Prepared aqueous extract (10gm/100ml) of leaves and mixed with vermicompost in 1:100 ratio.

2.5. Extraction of nematodes from soil

Soil sample were collected from different experimental sites. Soils from 20 cm depth were used for the analysis of nematode. A small amount of soil (100 cm3) of each samples were collected from the experimental field. Nematodes were extracted from soil using Cobb's Sieving and gravity methods [16]. The samples were passed through sieves and the finally centrifuged for one minute. Nematode was identified through their taxonomic character. Their number was counted with the help of microscope.

Vermicompost obtained from different combination of animal and agro wastes in single and binary combination with biopesticide (neem oil, leaves extract of custard apple and garlic extract) were mixed @ 2 kg/m2 experimental area. Number of nematodes at pre and after mixing of vermicomposts in soil was counted with the help of microscope.

2.6. Experimental design of crops for measurement of growth, flowering period and productivity

Measurement of growth, flowering period and productivity of crops were performed in the experimental field of Vermiculture Research Center, Department of Zoology, D.D.U. Gorakhpur University. The 40 days old seedlings of tomato (*Lycopersicon esculentum*) variety HS-102 crops were planted in the experimental field/squire meter in each. Growth of crop was measured by auxanometer after 20 days from plantation. Flowering period were observed in adults plants. Productivity (kg/m2) of tomato was measured in each experimental field.

2.7. Chemical analysis

The chemical analysis of raw organic wastes and final vermicompost were determined by standard methods. Total organic carbon (TOC) was measured by the method of [17]. Total Kjeldahl nitrogen was determined by the method of Bremner and Mulvaney [18]. Total available phosphorus (TAP) was determined by colorimetric method of Bansal and Kapoor [19]. Total Potassium and Calcium were determined by flame photometer [19]. The pH and electrical conductivity (EC) were determined by with the help of pH and conductivity meter.

2.8. Statistical analysis

The value is expressed as mean ± SE of 6 replicates. Two way analysis of variance (ANOVA) was applied to determined the significant ($P<0.05$) difference among the number of nematodes in control and treaded group. One way analysis of variance was applied to locate significant ($P<0.05$) difference between flowering and productivity of crop with respect to different formulations of vermicompost [20].

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[III] RESULTS

The combination of vermicompost with biopesticide viz. neem (Azadirachta indica) oil, aqueous extract of garlic (Allium sativum) and leaves extract of custard apple (Annona squamosa) caused a significant ($P<0.05$) reduction in pest infestation and increase in plant growth, early flowering and productivity of the tomato crop. Significant reduction in number of nematodes population was observed in the soil mixed with vermicompost containing biopsticides **[Suplimentary Table–1 and 4]**.The different combination of vermicompost with garlic extract and animal dung + gram bran with neem oil have caused the complete control of soil nematodes infestation in tomato crops **[Supplementary Tables–2 and 3].**

Growth of tomato plant in control group was 10.20, 13.70 and 20.20 cm after 20, 30 and 40 days of plantation, respectively. Combinations of different animal dung + agro/kitchen wastes vermicomposts with biopesticides in the soil caused significant increase growth of tomato plant. The highest growth of tomato (38.02 cm) was observed in soil mixed with vermicompost of buffalo dung +gram bran + garlic extract, followed by vermicomposts of buffalo dung + gram bran + neem oil and buffalo dung + gram bran +leaf extract of custard apple **[Supplementary Tables– 2, 3, and 4].**

The flowering period of tomato in control group was 102.42 days. Significant early flowering was observed in all combination of vermicompost of different animal dung + agro/kitchen wastes singly, as well as binary combination with different biopesticide. The maximum significant early flowering period of tomato was 90.57 and 92.18 day shown in combination of vermicompost of buffalo dung + gram bran/goat dung + rice bran with neem oil **[Supplementary Table–2]**.

The significant increase in productivity of tomato was observed in all the combinations of vermicomposts of different animal, agro/ kitchen wastes singly and in binary combination with neem oil garlic extract and Annona squamosa leaf extract. The combinations of buffalo dung +gram bran with aqueous extract of garlic have maximum productivity of tomato (6.30 kg/m2) in comparison to all the biopesticide **[Supplementary Tables–2 and 3].**

[IV] DISCUSSION

It is evident from result section that the use of vermicompost obtained from different combinations of animal and agro/kitchen wastes singly as well as in combination with different biopesticides like neem (Azadirachta indica) oil, aqueous extract of garlic (Allium sativum) bulb and leaf extract of custard apple (Annona squamosa) [11, 13, 21] caused significant reduction in plant parasitic nematodes infestation in the soil, which ultimately enhances the growth, early flowering and productivity of tomato crop. Vermicompost of different animal-agro wastes have significant amount of nitrogen, phosphorus, Ca++, K+ vitamins, enzyme, plant hormones etc. [22-24] and plant pesticide viz neem (Azadirachta indica) oil, aqueous extract of garlic (Allium sativum) bulb and leaf extract of custard apple (Annona squamosa) have toxic effect against nematode infestation [11, 13, 21]. Akhtar and Mahmood [11] reported that addition of nitrogen based supplement along with organic amendments alter the soil texture, consequently number of nematodes in soil significantly reduced. Earthworms feed on the egg and larvae of soil nematode pest which ultimately reduced the soil nematode population [4, 25]. Meyer et al. [12] find similar result by the use of Syzygium arometicum against root knot nematodes Meloidigyne incognita. Musabyimana and Saxena [26] reported that garlic and neem seed derivatives were very effective against plant parasitic nematode (Pratylenchus sp.). Neem; garlic and custard apple are potent actively against different nematodes [13, 14].

The different combination of vermicompost obtained from different animal agro/kitchen wastes with garlic extract and vermicompost obtain from different animal dung +gram bran with neem oil shows total control of soil nematode pest. The reduction of nematode infestation may be due to the migration, poor penetration and retardation of different activities of nematodes in plant. Chemical content by the plant extract had the ability to affect the nervous system by inhibiting the activity of acetylcholinestrase in nematodes [28].

The highest growth of tomato was observed in vermicompost obtained from buffalo dung +gram bran in all the combination with biopesticide. Vermicompost of these combinations are the rich source of enzyme, vitamins plant growth hormones such as IAA, Gibbereline, Cytokinine along with micro and macro nutrients and due to the presence of biopesticides which enhance the growth of plant [24].

There was significant reduction in flowering period of tomato in all the combination of vermicomposts of different animal and agro wastes +neem oil/garlic/custard apple extract with respect to control. The combination of vermicompost with biopesticide caused early flowering of tomato plants, possibly due to the presence of TKN, TP in the vermicompost which stimulate the early flowering of crop [29-33]. The rich amount of TKN and TP stimulate the early flowering period of Daucus carota and tomato [34-36].

The combination of buffalo dung +gram bran with aqueous extract of garlic and neem oil shows significant maximum productivity of tomato it is due to the presence of essential nutrients in vermicompost which increased the metabolic activity of plant as well as garlic extract check the tomato infestation of nematodes [13, 31]. Large amount of humic acid were produced during vermicomposting which lowers the pH of soil and ultimately affect the productivity of plant [4]. Reduction of plant parasitic nematodes directly affects the

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productivity of crops [11, 26].

[V] CONCLUSION

It can be stated from the present study, that different combinations of vermicompost obtain from buffalo dung + gram bran with different biopesticides have significant effect on control of parasitic nematodes. Simultaneously, it also increases the growth, started early flowering and enhanced the productivity of tomato up to four times with respect to control. The use of each combination in the present study is easily producible, biodegradable, less expensive and cause no environment hazards to human health. These products will be ecologically safe and culturally more acceptable among farmers and live –stock keepers.

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SUPPLEMENTARY MATERIALS (As supplied by authors)

Supplementary Table-1: Effect of vermicomposts obtained from different animal dung and agro / kitchen wastes on nematode population in soil and growth as well as growth and productivity of tomato (*Lycopersicon esculentum*).

Combination	No. of nematodes		Growth of tomato (cm.)			Flowering period	Productivity
			Days after planting			(Days)	(kg/m^2)
	Before sowing	After harvesting	20	30	40		
Control	41.2±0.3	56.4±0.2	10.20±0.38	13.70±0.81	20.20±0.56	102.42±3.20	1.23±.24
Cow							
Dung	* 40.6±0.2	32.5±0.3	# 12.66±0.36	20.13±0.69	27.27±0.64	97.61±2.25	$ 3.06±.14
Dung +Rice Bran	42.5±0.1	31.3±0.2	* 13.22±0.49	29.46±0.51	35.10±0.46	96.54±2.88	4.07±.15
Dung +Wheat Bran	41.4±0.2	30.5±0.3	13.26±0.69	21.97±0.42	30.51±0.64	96.46±3.47	4.72±.21
Dung +Straw	42.6±0.3	28.4±0.2	15.65±0.55	22.56±0.83	34.44±0.62	97.94±2.56	3.00±.16
Dung +Vegetables	43.4±0.2	31.6±0.2	12.76±0.76	24.91±0.92	32.56±0.66	96.86±2.78	3.98±.08
Dung +Barely Bran	40.2±0.3	32.9±0.1	15.32±0.82	21.94±0.44	33.28±0.92	99.25±2.64	5.08±.25
Dung +Gram Bran	43.3±0.2	28.8±0.3	13.13±0.84	22.89±0.29	30.29±0.36	100.73±2.47	4.80±.42
Buffalo							
Dung	* 40.2±0.2	31.3±0.1	# 10.52±0.44	20.03±0.24	26.17±0.16	97.26±2.24	$ 3.12±.72
Dung + Rice Bran	41.4±0.3	32.3±0.3	* 14.15±0.49	20.42±0.97	34.42±0.88	96.42±1.46	3.62±.71
Dung + Wheat Bran	42.6±0.2	31.5±0.2	13.22±0.89	20.92±0.45	33.07±0.49	96.23±2.96	4.68±.26
Dung + Straw	44.4±0.2	28.4±0.3	13.21±0.94	22.03±0.88	31.21±0.52	97.82±1.86	3.30±.38
Dung + Vegetables	42.3±0.2	28.6±0.2	14.29±0.94	23.47±0.67	33.55±0.92	96.80±2.74	3.42±.24
Dung + Barley Bran	42.4±0.2	31.4±0.2	12.39±0.66	22.79±0.56	33.50±0.33	99.49±2.54	4.80±.40
Dung + Gram Bran	40.8±0.3	27.8±0.1	15.88±0.58	24.58±0.66	**35.35±0.33**	95.47±2.22	**5.18±.46**
Sheep							
Dung	* 42.3±0.0	32.3±0.2	# 10.56±0.22	17.45±0.19	23.64±0.28	100.99±2.24	$ 3.07±.39
Dung +Rice Bran	43.5±0.3	31.5±0.2	* 09.98±0.39	17.53±0.43	23.10±0.43	101.45±2.25	4.02±.20
Dung + Wheat Bran	42.4±0.1	30.4±0.3	12.29±0.39	17.13±0.57	24.15±0.59	101.86±2.63	3.86±.30
Dung + Straw	43.3±0.1	29.7±0.1	11.28±0.96	20.18±0.88	30.26±0.43	100.55±4.85	4.09±.21
Dung + Vegetables	40.5±0.3	28.3±0.2	11.35±0.88	21.00±0.78	29.94±0.60	100.86±3.64	5.08±.26
Dung + Barley Bran	41.4±0.2	33.7±0.2	12.28±0.60	20.22±0.33	30.23±0.73	100.35±3.86	3.14±.26
Dung + Gram Bran	40.6±0.1	31.6±0.3	10.36±0.40	20.18±0.46	31.44±0.83	100.32±2.16	4.02±.43
Goat							
Dung	* 40.9±0.2	313.±0.3	# 10.56±0.30	21.00±0.64	29.30±0.60	100.53±0.87	$ 3.02±.65
Dung + Rice Bran	42.8±0.1	30.8±0.1	* 11.84±0.41	21.13±0.72	31.19±0.58	94.18±2.56	3.40±.41
Dung + Wheat Bran	42.7±0.0	34.2±0.4	10.53±0.92	20.08±0.75	30.44±0.42	100.54±0.87	4.09±.44
Dung + Straw	41.2±0.0	30.5±0.1	09.92±0.84	19.66±0.76	31.00±0.43	101.49±2.28	3.10±.62
Dung + Vegetable	41.3±0.2	31.6±0.0	11.47±0.75	20.77±0.55	28.80±0.43	99.76±2.57	3.36±.44
Dung + Barley Bran	41.2±0.1	32.8±0.1	11.28±0.52	20.19±0.57	30.72±0.55	100.55±2.54	5.00±.43
Dung + Gram Bran	43.4±0.2	32.3±0.1	10.35±0.48	20.51±0.52	29.33±0.88	100.86±3.22	4.00±.30
Horse							
Dung	* 44.2±0.1	28.4±0.2	#09.42±0.31	19.49±0.35	25.56±0.56	99.25±1.57	$ 3.04±.21
Dung + Rice Bran	42.4±0.2	29.6±0.2	* 12.32±0.75	21.33±0.76	33.89±0.60	96.57±2.43	3.85±.20
Dung + Wheat Bran	40.5±0.2	30.7±0.1	12.83±0.69	20.93±0.54	32.24±0.58	95.68±0.45	4.05±.34
Dung + Straw	42.6±0.3	29.6±0.1	13.24±0.25	21.96±0.44	31.52±0.53	97.84±0.56	2.09±.49
Dung + Vegetable	41.4±0.1	28.5±0.2	15.51±0.48	21.43±0.64	32.34±0.55	96.46±2.88	3.15±.14
Dung + Barley Bran	40.7±0.3	33.4±0.4	16.22±0.62	20.98±0.45	32.52±0.53	100.75±2.37	4.98±.21
Dung + Gram Bran	42.2±0.0	27.2±0.3	15.87±0.63	20.81±0.52	31.33±0.49	101.56±3.01	3.91±.32

Each value is the mean ± SE of six replicates.
2way ANOVA: Significant (P<0.05) * within column, # within row.
$- Significant one way ANOVA (P<0.05) within row.

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Supplementary Table-2: Effect of combinations (1:1000) of neem oil with vermicomposts obtain from different animal dung and agro / kitchen wastes on nematode population in soil as well as growth and productivity of tomato (*Lycopersicon esculentum*).

Combination	No. of nematodes		Growth of tomato (cm.)			Flowering period	Productivity
	Before sowing	After harvesting	20	30	40		
Control	41.2±0.3	56.4±0.2	10.20±0.38	13.70±0.81	20.20±0.56	102.42±3.20	1.23±.24
Cow							
Dung	* 40.4±0.2	3.6±0.1	# 13.76±0.36	22.13±0.49	29.07±0.34	95.81±0.26	$ 3.86±.24
Dung +Rice Bran	41.3±0.3	3.5±0.0	* 14.20±0.49	24.46±0.81	36.00±0.76	94.14±1.83	4.97±.25
Dung +Wheat Bran	43.3±0.2	1.6±0.0	14.96±0.59	23.97±0.52	32.01±0.54	94.56±2.27	5.12±.11
Dung +Straw	42.6±0.3	3.7±0.1	16.55±0.45	25.56±0.81	36.40±0.64	95.90±2.56	4.00±.06
Dung +Vegetables	40.5±0.1	4.4±0.2	13.76±0.66	24.71±0.97	34.59±0.46	94.82±2.77	4.98±.05
Dung +Barely Bran	43.4±0.3	4.5±0.1	16.22±0.81	24.64±0.54	35.08±0.93	97.20±1.66	5.08±.45
Dung +Gram Bran	44.8±0.2	Nil	14.13±0.84	24.89±0.69	32.89±0.39	98.75±1.45	5.50±.40
Buffalo							
Dung	* 41.7±0.0	2.6±0.1	# 12.51±0.41	22.02±0.34	28.07±0.19	95.28±1.25	$ 3.92±.70
Dung + Rice Bran	41.2±0.1	2.5±0.1	* 15.16±0.44	23.52±0.96	36.40±0.48	94.44±1.26	4.22±.71
Dung + Wheat Bran	41.6±0.2	3.8±0.3	14.26±0.89	23.82±0.49	35.09±0.59	94.21±0.96	5.08±.22
Dung + Straw	42.4±0.1	3.3±0.0	14.21±0.96	24.02±0.89	33.11±0.92	95.80±0.83	4.10±.18
Dung + Vegetables	43.6±0.3	3.5±0.1	15.29±0.90	25.47±0.61	35.45±0.93	94.70±1.54	4.12±.14
Dung + Barley Bran	40.6±0.1	4.4±0.1	15.79±0.67	24.79±0.46	35.00±0.63	97.09±1.50	5.80±.43
Dung + Gram Bran	43.3±0.2	Nil	16.86±0.53	24.78±0.86	**37.38±0.38**	90.57±1.23	**5.98±.66**
Sheep							
Dung	* 42.2±0.0	2.7±0.1	# 11.56±0.21	19.43±0.09	25.60±0.29	99.19±0.25	$ 3.97±.29
Dung +Rice Bran	41.1±0.1	3.4±0.0	* 09.98±0.31	18.83±0.40	25.00±0.42	100.15±1.15	4.92±.30
Dung + Wheat Bran	40.4±0.2	2.5±0.1	13.20±0.33	19.03±0.47	26.11±0.39	100.76±1.83	4.46±.10
Dung + Straw	41.7±0.1	Nil	13.18±0.96	22.08±0.83	32.21±0.83	101.25±2.80	5.09±.11
Dung + Vegetables	43.6±0.3	3.4±0.1	12.25±0.88	23.00±0.77	31.94±0.66	101.86±2.60	5.48±.06
Dung + Barley Bran	40.6±0.1	4.4±0.0	14.28±0.69	22.32±0.30	32.13±0.77	100.25±2.80	4.14±.06
Dung + Gram Bran	43.0±0.2	Nil	12.26±0.44	22.08±0.66	33.34±0.86	100.35±2.19	5.02±.43
Goat							
Dung	* 43.3±0.3	2.4±0.1	# 12.55±0.35	23.00±0.60	31.20±0.60	100.52±0.47	$ 3.92±.95
Dung + Rice Bran	41.2±0.2	2.5±0.0	* 13.80±0.47	23.03±0.73	33.09±0.59	92.18±1.56	4.40±.81
Dung + Wheat Bran	41.6±0.2	3.2±0.1	12.57±0.91	21.98±0.74	32.84±0.82	99.64±0.77	5.09±.74
Dung + Straw	40.4±0.0	Nil	12.98±0.83	21.66±0.79	33.00±0.41	100.19±1.18	4.10±.60
Dung + Vegetable	42.7±0.2	1.5±0.1	13.42±0.78	22.73±0.59	30.85±0.63	98.74±2.97	4.26±.54
Dung + Barley Bran	41.6±0.4	4.3±0.0	13.18±0.51	22.09±0.59	32.72±0.53	101.25±2.04	5.80±.49
Dung + Gram Bran	42.3±0.3	Nil	12.33±0.49	22.91±0.51	31.31±0.98	100.76±2.20	4.90±.34
Horse							
Dung	* 42.3±0.0	2.2±0.1	# 10.41±0.39	21.29±0.25	27.52±0.46	98.21±1.27	$ 3.94±.25
Dung + Rice Bran	45.5±0.1	Nil	* 13.31±0.76	23.43±0.78	35.79±0.68	95.17±2.03	4.45±.20
Dung + Wheat Bran	42.4±0.2	Nil	13.88±0.89	22.91±0.64	34.04±0.88	95.68±0.45	5.05±.31
Dung + Straw	43.6±0.1	Nil	15.23±0.45	23.90±0.64	33.02±0.54	96.84±0.96	2.99±.09
Dung + Vegetable	43.4±0.3	3.4±0.1	16.56±0.43	23.73±0.34	34.24±0.50	95.45±1.83	4.15±.04
Dung + Barley Bran	40.5±0.1	4.3±0.0	15.23±0.69	23.08±0.46	34.50±0.59	100.77±2.07	5.78±.01
Dung + Gram Bran	43.5±0.2	Nil	14.86±0.63	23.01±0.52	33.53±0.79	101.56±2.01	4.91±.02

Each value is the mean ± SE of six replicates.
2way ANOVA: Significant (P<0.05) * within column, # within row.
$-Significant one way ANOVA (P<0.05) within row.

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Supplementary Table-3: Effect of combinations (1:100) of aqueous extract of garlic bulb with vermicomposts obtain from different animal dung and agro / kitchen wastes on nematode population in soil as well as growth and productivity of tomato (*Lycopersicon esculentum*).

Combination	No. of nematodes		Growth of tomato (cm.)			Flowering period	Productivity
			Days after planting			(Days)	(kg/m^2)
	Before sowing	After harvesting	20	30	40		
Control	41.2±0.3	56.4±0.2	10.20±0.38	13.70±0.81	20.20±0.56	102.42±3.20	1.23±.24
Cow							
Dung	* 42.4±0.3	Nil	# 14.26±0.26	23.13±0.45	29.97±0.45	**94.36±0.45**	$ 3.98±.23
Dung +Rice Bran	40.3±0.1	Nil	* 15.22±0.43	25.02±0.47	37.20±0.16	**93.54±1.52**	5.27±.72
Dung +Wheat Bran	43.6±0.2	1.6±0.0	15.46±0.49	24.27±0.43	33.31±0.53	93.86±1.83	5.64±.53
Dung +Straw	40.8±0.1	2.2±0.1	17.54±0.46	26.16±0.43	37.10±0.43	94.90±2.43	4.52±.16
Dung +Vegetables	42.7±0.2	3.5±0.0	14.66±0.36	25.01±0.46	35.29±0.53	94.02±1.23	4.98±.05
Dung +Barely Bran	43.9±0.2	2.5±0.1	17.25±0.21	25.14±0.52	36.08±0.46	96.80±1.45	6.08±.92
Dung +Gram Bran	42.4±0.1	Nil	15.23±0.87	25.19±0.65	33.29±0.73	97.74±2.73	5.96±.43
Buffalo							
Dung	* 41.4±0.3	Nil	# 13.61±0.42	22.52±0.30	29.17±0.76	94.58±2.43	$ 4.12±.45
Dung + Rice Bran	42.5±0.3	2.4±0.1	* 16.16±0.44	24.02±0.23	37.23±0.56	93.84±2.63	4.86±.48
Dung + Wheat Bran	40.6±0.1	Nil	15.36±0.49	24.12±0.46	36.19±0.84	93.83±0.42	5.76±.56
Dung + Straw	43.5±0.2	1.4±0.0	15.61±0.36	24.52±0.69	34.01±0.49	94.83±2.54	4.84±.73
Dung + Vegetables	40.9±0.1	Nil	16.39±0.95	25.97±0.64	36.25±0.34	93.70±2.43	4.97±.74
Dung + Barley Bran	42.4±0.2	3.2±0.1	16.49±0.64	25.18±0.40	34.10±0.52	96.59±3.55	5.08±.46
Dung + Gram Bran	43.4±0.2	Nil	14.83±0.56	25.19±0.56	**38.02±0.28**	97.87±3.43	**6.30±.46**
Sheep							
Dung	* 41.6±0.3	Nil	# 12.46±0.26	19.83±0.59	26.32±0.46	97.59±2.58	$ 4.10±.54
Dung +Rice Bran	42.2±0.0	2.6±0.1	* 10.38±0.36	19.23±0.23	26.12±0.64	98.95±2.84	5.06±.82
Dung + Wheat Bran	41.3±0.1	Nil	14.26±0.34	19.83±0.46	27.23±0.09	99.76±2.83	4.96±.73
Dung + Straw	43.5±0.2	1.4±0.0	14.28±0.36	22.98±0.80	33.21±0.13	101.25±1.82	5.79±.48
Dung + Vegetables	41.7±0.1	3.5±0.l	13.24±0.48	24.00±0.74	32.54±0.47	101.86±1.64	6.12±.47
Dung + Barley Bran	42.6±0.3	Nil	15.38±0.49	23.12±0.61	33.03±0.26	101.53±1.86	4.64±.23
Dung + Gram Bran	42.9±0.1	Nil	13.66±0.54	22.88±0.64	34.14±0.46	100.73±3.42	5.52±.46
Goat							
Dung	* 42.5±0.1	Nil	# 13.15±0.25	23.50±0.64	32.00±0.36	99.62±0.47	$ 4.23±.56
Dung + Rice Bran	43.3±0.1	2.2±0.1	* 14.20±0.43	23.93±0.75	34.09±0.29	96.88±1.56	5.00±.47
Dung + Wheat Bran	42.5±0.3	Nil	13.47±0.96	22.38±0.54	32.84±0.82	99.64±0.77	5.59±.85
Dung + Straw	42.6±0.3	1.5±0.0	13.38±0.43	22.26±0.75	33.00±0.41	100.89±2.48	4.94±.90
Dung + Vegetable	40.3±0.4	Nil	14.32±0.58	23.13±0.50	30.85±0.63	97.52±3.93	4.98±.54
Dung + Barley Bran	40.8±0.2	2.2±0.l	14.48±0.52	22.89±0.49	32.72±0.53	101.45±3.04	6.16±.46
Dung + Gram Bran	41.4±0.0	Nil	13.36±0.59	23.24±0.52	31.31±0.98	101.83±0.48	5.14±.75
Horse							
Dung	* 41.3±0.3	Nil	# 11.44±0.33	21.99±0.22	27.52±0.46	97.29±2.45	$ 4.24±.46
Dung + Rice Bran	42.4±0.0	2.4±0.1	* 14.38±0.75	24.13±0.74	35.79±0.68	94.48±2.46	4.96±.56
Dung + Wheat Bran	41.3±0.1	Nil	14.23±0.80	23.96±0.60	34.04±0.88	94.98±2.82	5.85±.48
Dung + Straw	43.6±0.2	1.5±0.0	16.33±0.46	24.92±0.34	33.02±0.54	95.24±1.36	3.16±.22
Dung + Vegetable	41.4±0.1	Nil	16.66±0.42	24.53±0.64	34.24±0.50	94.46±2.80	4.85±.43
Dung + Barley Bran	42.3±0.3	Nil	16.23±0.69	24.18±0.45	34.50±0.59	101.42±1.47	6.13±.43
Dung + Gram Bran	42.4±0.1	Nil	15.16±0.23	24.01±0.53	33.53±0.79	100.72±2.51	5.15±.45

Each value is the mean ± SE of six replicates.
2way ANOVA: Significant (P<0.05) * within column, # within row.
$- Significant one way ANOVA (P<0.05) within row.

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Supplementary Table-4: Effect of combinations (1:100) of aqueous leaf extract of custard apple (Annona squamosa) with vermicomposts obtain from different animal dung and agro / kitchen wastes on nematode population in soil as well as growth and productivity of tomato (Lycopersicon *esculentum*)

Combination	No. of nematodes		Growth of tomato (cm.)			Flowering period	Productivity
			Days after planting			(Days)	(kg/m^2)
	Before sowing	After harvesting	20	30	40		
Control	41.2±0.3	56.4±0.2	10.20±0.38	3.70±0.81	20.20±0.56	102.42±3.20	1.23±.24
Cow							
Dung	* 42.2±0.3	5.1±0.2	# 13.55±0.46	20.89±0.54	27.98±0.75	97.03±2.45	$ 3.21±.23
Dung +Rice Bran	40.2±0.2	6.2±0.2	* 13.82±0.43	30.12±0.42	35.84±0.47	96.21±1.47	4.15±.15
Dung +Wheat Bran	40.3±0.3	7.1±0.3	13.93±0.43	22.46±0.47	31.12±0.48	96.42±3.42	4.82±.14
Dung +Straw	41.4±0.2	8.2±0.2	16.12±0.42	23.13±0.32	34.98±0.24	97.14±3.14	3.15±.17
Dung +Vegetables	43.2±0.3	5.3±0.3	13.13±0.43	25.24±0.34	33.12±0.28	96.24±2.23	4.02±.21
Dung +Barely Bran	42.4±0.4	5.3±0.1	15.75±0.73	22.23±0.43	33.98±0.48	99.01±2.24	5.15±.31
Dung +Gram Bran	42.3±0.3	8.5±0.2	13.45±0.23	23.43±0.28	30.85±0.17	100.04±1.24	4.97±.28
Buffalo							
Dung	* 40.2±0.3	5.4±0.4	# 10.98±0.73	20.86±0.23	26.67±0.25	97.14±3.24	$ 3.42±.14
Dung + Rice Bran	42.3±0.2	8.4±0.2	* 14.83±0.43	20.98±0.24	34.87±0.46	96.14±2.43	3.52±.42
Dung + Wheat Bran	41.4±0.1	5.2±0.5	13.86±0.34	21.23±0.43	33.75±0.15	96.27±2.96	4.76±.17
Dung + Straw	43.6±0.2	7.3±0.4	13.87±0.34	22.65±0.88	31.86±0.47	97.47±1.24	3.46±.24
Dung + Vegetables	42.3±0.3	5.2±0.4	14.97±0.45	23.98±0.42	34.13±0.45	96.15±1.28	3.54±.47
Dung + Barley Bran	41.2±0.3	6.2±0.5	12.98±0.43	23.12±0.43	33.90±0.27	99.17±2.28	4.94±.42
Dung + Gram Bran	41.5±0.3	3.2±0.4	16.14±0.45	30.23±0.45	**35.95±0.45**	95.45±2.21	**5.42±.14**
Sheep							
Dung	* 41.0±0.1	7.6±0.3	# 11.45±0.42	17.90±0.74	23.85±0.52	100.24±2.24	$ 3.12±.47
Dung +Rice Bran	42.3±0.2	5.6±0.3	* 10.24±0.42	17.96±0.45	23.64±0.24	101.45±4.21	4.23±.14
Dung + Wheat Bran	41.4±0.2	6.5±0.7	12.89±0.23	17.68±0.25	24.84±0.18	101.32±2.14	4.02±.45
Dung + Straw	42.2±0.3	7.6±0.8	11.78±0.45	20.97±0.57	30.79±0.48	100.24±2.45	4.42±.14
Dung + Vegetables	41.5±0.2	7.3±0.4	12.05±0.28	21.75±0.76	29.98±0.48	100.48±2.17	5.23±.42
Dung + Barley Bran	40.2±0.1	7.3±0.4	12.96±0.43	20.97±0.45	31.13±0.47	100.20±3.24	3.43±.18
Dung + Gram Bran	42.6±0.3	6.5±0.2	11.03±0.43	20.97±0.43	32.13±0.14	101.21±2.14	4.14±.24
Goat							
Dung	* 41.5±0.3	7.8±0.5	# 11.21±0.25	21.79±0.34	29.89±0.89	100.17±0.48	$ 3.23±.24
Dung + Rice Bran	40.8±0.2	7.5±0.4	* 12.24±0.45	21.95±0.35	31.79±0.79	**94.02±2.17**	3.43±.24
Dung + Wheat Bran	41.6±0.1	6.5±0.4	11.23±0.25	20.73±0.64	30.89±0.27	100.05±0.48	4.56±.25
Dung + Straw	42.6±0.2	6.7±0.6	10.12±0.23	20.12±0.47	31.56±0.47	101.04±2.17	3.28±.24
Dung + Vegetable	42.4±0.1	6.5±0.8	12.42±0.24	21.24±0.42	29.24±0.17	99.03±2.18	3.54±.52
Dung + Barley Bran	43.4±0.2	6.7±0.7	11.84±0.23	20.95±0.42	31.28±0.18	100.45±2.24	5.12±.15
Dung + Gram Bran	43.6±0.2	5.8±0.4	11.23±0.14	21.12±0.23	29.98±0.47	100.17±3.23	4.15±.24
Horse							
Dung	* 43.4±0.2	8.7±0.6	# 10.23±0.24	19.97±0.28	26.23±0.12	99.47±1.45	$ 3.20±.23
Dung + Rice Bran	41.8±0.3	5.7±0.4	* 13.15±0.42	21.95±0.54	34.12±0.14	96.02±2.15	3.85±.24
Dung + Wheat Bran	41.4±0.2	5.6±0.6	13.53±0.45	21.42±0.15	32.95±0.45	95.32±0.17	4.24±.14
Dung + Straw	41.6±0.2	7.5±0.7	14.12±0.32	22.42±0.45	31.90±0.14	97.24±0.15	2.14±.32
Dung + Vegetable	43.7±0.2	5.7±0.8	16.12±0.43	21.98±0.14	32.96±0.47	96.24±2.14	3.24±.14
Dung + Barley Bran	41.6±0.2	7.5±0.7	16.89±0.24	21.46±0.23	32.95±0.41	100.14±2.24	5.14±.34
Dung + Gram Bran	42.2±0.6	6.5±0.9	16.23±0.34	21.15±0.14	31.97±0.45	100.42±3.21	4.02±.24

Each value is the mean ± SE of six replicates.
2way ANOVA: Significant (P<0.05) * within column, # within row.
$- Significant one way ANOVA (P<0.05) within row.