Review of Plant Studies
2015 Vol. 2, No. 2, pp. 9-18
ISSN(e): 2410-2970
ISSN(p): 2412-365X
DOI: 10.18488/journal.69/2015.2.2/69.2.9.18

MANAGEMENT OF ROOT-KNOT NEMATODE, MELOIDOGYNE JAVANICA INFECTING SUNFLOWER BY SOME COMPOSTED PLANT OR ANIMAL RESIDUES AS SOIL AMENDMENTS IN EGYPT

A.E. Ismail[1]
[1]*Departement of Plant Pathology, Nematology Laboratory, National Research Center, Dokki, Giza, Egypt*

ABSTRACT

Soil amendment with organic composts of plant or animal residues i.e. banana tree (BT), maize stalks (MS), sawdust (SD), rice straw (RS) and cattle dung (CD) at rates 0.25, 0.5 and 1.0 % w/w showed significant (P≤ 0.05 and / or 0.01) reduction in numbers of root knot nematode, Meloidogyne javanica larvae in soil, galls and egg-masses on roots as well as the nematode build-up as compared to control. All dosages of BT compost were most effective in reducing numbers of the nematode stages, galls, egg masses and the nematode build-up followed by 1.0% of both MS and SD composts. All doses of organic composts significantly (P≤ 0.05 and / or 0.01) increased growth of sunflower cv. Giza 1. and improvement of sunflower cv. Giza 1 growth. Generally, there were positive significant correlations between doses of composts and reduction percentages in number of larvae in soil, galls, egg-masses and rate of build-up, and (r = 0.9884, 1.045, 0.9844 and 0.9677; respectively) as well as increases in sunflower growth parameters in terms of lengths, fresh and dry weights of both shoots and roots (r = 0.9977, 1.0, 1.0, 0.9391, 0.9967 and 1.0; respectively). Also, there were positive significant relationship between shoot dry weight and each of N, P and K uptake by sunflower shoot (r = 0.9876, 1.0 and 0.9445; respectively), between root dry weight and N uptake (r = 1.0).

Keywords: Root-knot nematode, Meloidogyne javanica, Sunflower, Soil amendments, Plant or animal residues, Egypt.

1. INTRODUCTION

It is known that the root-knot nematodes, *Meloidogyne* spp. attack sunflower roots and severely reduce plant growth. Elimination of the nematodes has received attention to minimize damage to plants. Chemical nematicides have efficiently been used for a long time. However, hazards resulting from such chemicals encourage scientists to search for other alternatives. Cooke [1] found that organic composts supply both major and minor nutrients for the plant and also improve the physical conditions of the soil. Hsieh, et al. [2] found that chicken manure compoted with a microbial supplement showed up to 77% increase in yield of sweet pepper as compared to chemical treatment. Several workers have obtained significant reduction in the nematode infestation on various crops by soil amendments with organic composts of plant or animal origins [3-9]. However, the use of certain composted organic materials such as rice straw compost, banana tree compost and maize stalks compost against nematode populations has not received enough studies locally and needs elucidation. Hence, this manuscript was carried out to evaluate the role of these composts in the management of root-knot nematode, *Meloidogyne javanica* infecting sunflower cv. Giza 1 under greenhouse conditions.

2. MATERIALS AND METHODS

The pot experiment was carried out under greenhouse conditions 30 ± 3 °C at National Research Center in Giza governorate, Egypt. The experiment was conducted twice (2014 and 2015) and the data generated were pooled together for analysis. Five organic plant or animal residues viz., banana tree (BT), maiza stalks (MS), and sawdust (SD), rice straw (RS) and cattle dung (CD) were prepared as composts (Table 1). About 100 kg of each of the residues were air-dried, ground and mixed with 10% of cow dung in static vessels. Composts were turned over every 10 days for aeration and water was added to adjust the moisture content at 60% W.H.C. After 180 days, the end products were taken to evaluate their effectiveness against *Meloidogyne javanica* and plant growth response of sunflower. The composts were applied in the form of powder, mixed thoroughly with autoclaved soil mixture (sand : clay, 1 : 1, v : v) with pH 7.8 and E.C. 0.51 at 0.25, 0.5 and 1% w/w [equivalent to 2.5, 5 and 10 tons / feddan (= 4200 m 2)] and transferred into 20 cm diam., clay pots containing 2 kg soil per pot. Four seeds of sunflower cv. Giza 2 were sown in each pot and after germination only one healthy plant was kept in each pot. After 15 days of germination, each plant was inoculated with 1500 of infective stages (J_2) of *M. javanica* at the base of the standing plant. Nematode inoculated untreated pots served as control. Treatments were replicated six times and the pots were arranged in a randomized complete block design in a greenhouse. After 70 days of nematode inoculation, sunflower plants were carefully uprooted and nematodes in pot soil and on sunflower roots were counted. Length, fresh and dry weight of shoots and roots were also recorded. The percentages reduction or increase in nematode populations or plant growth parameters as compared to untreated pots were calculated. Both dry roots and dry shoots were ground for chemical analysis according to Cottenie, et al. [10].

2.1. Data Collection and Analysis

In both experiments, the obtained data on cowpea growth components (lengths and fresh weights of both shoot and root growth) were collected. Data were also collected on number of larvae in soil, both galls and egg-masses on roots, total final nematode population as well as the nematode build-up from all the treatments. All the data were pooled together and means were analysed statistically using the Fisher's Least Significant Difference (L.S.D.). Correlation analyses were also used to determine the relationships between doses of composts and the reductions in nematode stages, galls, egg-masses and rates of build-up, increases in the plant growth parameters and between the uptake of some macronutrients and dry weight of sunflower.

Table-1. Chemical analysis of the tested organic composts.

Composts	Total nitrogen%	Organic carbon%	Organic matter%	C:N	pH*
Banana tree (BT)	1.44	28.07	44.28	19.5 : 1	8.50
Maize stalks (MS)	2.18	28.25	48.72	13.0 : 1	6.98
Sawdust (SD)	1.70	41.89	72.23	24.6 : 1	6.00
Rice straw (RS)	1.37	25.74	44.38	18.8 : 1	6.17
Cattle dung (CD)	1.81	17.53	30.22	9.7 : 1	8.68

*pH = 1: 2.5 soil: water ratio.

3. RESULTS

Statistical analysis of the data (Table 2) showed that all the tested organic composts significantly ($P\leq 0.05$ and / or 0.01) decreased , with few exceptions, the numbers of larvae in soil, galls and egg-masses on roots, total nematode populations and rate of build – up as compared to control. All doses (0.25, 0.5 and 1.0 % w/w) of the organic composts except the low dose of SD and all doses of CD significantly ($P\leq 0.01$) reduced numbers of galls as compared to control. Regarding egg-masses, all doses (0.25, 0.5 and 1.0 % w/w) of the organic treatments except the low dose of CD significantly ($P\leq 0.01$) reduced numbers of egg-masses as compared to control. Also, statistical differences at 0.05 and or 0.01 levels in the previous nematode stages and rate of build-up were observed within some treatments. Application of both doses 0.5 % and 1.0 % of BT compost sustained the least number of larvae in soil (1100 and 920; respectively),however all levels of the same substance showed the least numbers of both galls and egg-masses on roots (19, 20 and 3 for galls and 16, 17 and 2 for egg-masses) followed by 1.0% dose of MS compost in case of numbers of larvae in soil (1370 / pot) and 1.0% dose of RS compost in case of galls (20 galls / root) and egg-masses (16 / root) compared to similar dosages of the rest composts. Using of both 0.5% and 1.0% doses of BT treatment had the lowest values of the nematode build-up (0.8 and 0.6; respectively) followed by 1.0% dose of MS compost (1.0). Generally, there were positive significant correlations between reduction percentages in number of larvae in soil, galls, egg-masses and rate of build-up, and doses of the tested organic composts (r = 0.9884, 1.045, 0.9844 and 0.9677; respectively) as shown in table 2.

Most of the tested organic composts except BT compost improved the plant growth (Table 3). The best results were obtained with SD compost which showed significant ($P\leq 0.05$ and / or

0.01) improvement in dry shoot weight and all parameters of root growth, RS compost which significantly ($P \leq 0.05$ and / or 0.01) improved length, fresh and dry weights of shoot and some parameters of root growth, and MS compost which significantly increased length of shoot (Table 3).Generally, there were positive significant correlations between increase in the lengths, fresh and dry weights of both shoots and roots and doses of the composts ($r = 0.9977$, 1.0, 1.0, 0.9391, 0.9967 and 1.0; respectively).

Data in Table 4 revealed that the amount of macro plant nutrients which uptake by shoots and roots were dependent upon the type of compost and its application dose (Table 4). Most of the tested organic composts lead to increment in the amount of nutrients absorb over control. All organic composts, except 0.25% rate of CD compost increased N% in shoot over the control. Also, all organic composts except 0.25 dose of BT, SD, RS and CD composts increased K% in shoot over the control. Application of different organic composts had no / or slight effect of N% uptake by roots (Table 4). There was a marked effect of organic composts on the availability of organic carbon (OC), organic matter (OM) and E.C. Also, there was a marked effect of both SD and RS composts on soil pH while the rest organic composts were less effective. Statistical analyses revealed that there were positive significant relationship between shoot dry weight and each of N, P and K uptake by sunflower shoot ($r = 0.9876$, 1.0 and 0.9445; respectively).Also, there was positive significant relationship between root dry weight and N uptake ($r = 1.0$) as shown in table 4.

4. DISCUSSION

The antagonistic action of organic composts against *M. javanica* caused remarkable reduction in the nematode developmental stages in both soil and roots and their build-up and consequently all treatments showed improvement in all plant growth parameters as compared to unamended plants. This may be due to the accumulated toxicity of the decomposing composts [3, 7, 8, 11, 12] or due to an improvement in host tolerance to nematodes [6, 7, 13-17] or shifts in microbial populations and their activity in soil [18, 19]. Cook and Baker [20] also reported that antagonists of plant pathogens have been isolated from organic composts. The three doses of BT compost achieve best results in controlling *M. javanica* on sunflower. Similarly, soil amended with MS compost, significantly suppressed the nematode development and their reproduction. The nematicidal activity of SD compost has already been reported by Rey [3]; Gul, et al. [4]; Waceke and Waudo [21] and Abd–El-Khair, et al. [22]. In general, materials with C : N ratios < 20 : 1 have more nematicidal activity [16, 23] as these composts may have C:N ratios ranging between 9.7:1 to 24.6:1. There is need to carry out further studies on BT compost to ensure the nematicidal active principle and its action. SD, RS and CD composts also showed reduction in total final numbers of the nematode stages and rate of build-up as compared to control. These data are in harmony with reports of Waceke and Waudo [21]; Abadir, et al. [19]; Aboul–Eid, et al. [7]; Ismail, et al. [8] and Ismail, et al. [24] who respectively reported that the application of different organic composts significantly suppressed the populations of plant –parasitic nematodes on the test crops.

Certain composts especially, BT compost significantly increased the root, shoot or soil nutrients. Saleh and Abd – Elfattah [25]; Aboul–Eid, et al. [7] and Ismail and Hasabo [26] have also reported that the organic composts increased the amount of macro and micro nutrients over the control.

Better growth of sunflower plants due to the addition of some organic composts may partially be due to the nematode elimination and / or that these additives have also acted as organic manures [19, 27, 28]. Besides, the roots of plants grown in amended soil undergo physiological changes which make the roots unfavourable for nematode penetration and feeding so, inducing certain degrees of resistance against nematode attack [13, 28]. Also, in the present study there was no sign of phytotoxicity due to various composts. Use of organic composts in the nematode management thus has an advantage over the use of nematicidal chemical, since it is less expensive, safer and easy to apply with no pollution risks and that it can improve oil structure and fertility.

Table-2. Effect of some composted plant or animal residues on the development and reproduction of *Meloidogyne javanica* (average of two seasons).

Substances	Dose % w/w	Final nematode population						Total (P_f)	Reduction %	Rate of build-up (P_f/P_i)*	Reduction %
		No. of larvae in soil / pot	Reduction %	No. of galls per root	Reduction %	No. of egg-masses per root	Reduction %				
Banana tree (BT)	0.25	1480	83.5	19	82.7	16	84.9	1515	83.5	1.01	63.4
	0.5	1100	87.8	20	81.8	17	84.0	1137	87.8	0.8	86.9
	1.0	920	89.8	3	92.3	2	98.1	925	90.0	0.6	90.2
Maize stalks (MS)	0.25	3610	59.8	40	63.6	36	66.0	3686	60.0	2.5	59.0
	0.5	3290	63.4	29	73.6	21	80.2	3340	64.0	2.2	63.9
	1.0	1370	84.8	30	72.7	27	74.5	1427	84.5	1.0	83.6
Sawdust (SD)	0.25	3720	58.6	80	27.3	71	66.7	3871	58.0	2.6	57.4
	0.5	3010	66.5	55	50.0	50	83.3	3115	66.2	2.1	65.6
	1.0	2800	68.9	31	71.8	29	83.3	2860	69.0	1.9	68.9
Rice straw (RS)	0.25	4020	55.3	50	54.6	47	55.7	4117	55.3	2.8	54.1
	0.5	3700	58.8	28	74.6	27	74.5	3755	59.2	2.5	59.0
	1.0	3100	65.5	20	82.8	16	84.9	3136	66.0	2.1	65.6
Cattle dung (CD)	0.25	4100	54.4	91	17.3	90	15.1	4281	53.5	2.9	52.5
	0.5	3700	58.8	78	29.1	75	29.3	3853	58.2	2.6	57.4
Control	1.0	2900	67.7	70	36.4	66	37.7	3036	67.0	2.0	67.2
	-----	8990		110		106		9206		6.1	
LSD 0.05		650		44		21		570		0.8	
LSD 0.01		879		55		28		910		1.0	

*P_i = initial population of nematode inoculum (1500 infective stage, J_2), P_f = final population of the nematode.

REFERENCES

[1] G. W. Cooke, *The control of soil fertility. "Oeganic manures"*. London: Book Society and Crosby Lockwook & Son Ltd, 1970.

[2] C. A. Hsieh, H. Kuonan, C. F. Hsieh, and K. N. Hsu, "Effect of organic manures on the growth and yield of sweet pepper," *Bulletin of Taihung – District Agric. Improvement Station*, vol. 42, pp. 1-10, 1994.

[3] D. D. Rey, "Populations of root – knot and reniform nematodes in soil amended with fresh and compoted organic materials," *Int. Nematol. Network Newl.*, vol. 5, pp. 24 -26, 1988.

[4] A. Gul, M. Saeed, and M. Saifullah, "A mode of action of different substances used for control of Meloidogyne javanica on tobacco and okra in N. W. F. P., Pakistan," *Afro- Asian J. Nematology*, vol. 1, pp. 23 – 29, 1991.

[5] A. Gamliel and J. J. Stapleton, "Effect of chicken compost or ammonium phosphate and solarization on pathogen control, rhizosphere microorganisms and lettuce growth," *Plant Disease*, vol. 77, pp. 886 – 891, 1993.

[6] R. McSorely and R. N. Gallaher, "Cultural practice improve crop tolerance to nematodes," *Nematropica*, vol. 25, pp. 53 – 60, 1995.

[7] H. Z. Aboul–Eid, A. E. Ismail, and A. A. El- Sayed, "Effects of certain composted plant residues on sunflower melianthus annuus infected with meloidogyne incognita," *Egyptian J. of Agronematology*, vol. 2, pp. 79 –95, 1998.

[8] A. E. Ismail, R. A. Eid, and W. M. A. El-Nagdi, "Effect of different composts, biofertilizer and olive pomace as soil amendments on rotylenchulus reniformis, growth and chemical analysis of jasmine in Egypt," *Journal of Applied Science Research*, vol. 2, pp. 909 – 919, 2006.

[9] H. Abouziena, A. Ismail, and S. Radwan, "Effect of bio-organic fertilizers, hoeing and polyethylene mulch on weeds, the citrus nematode (Tylenchulus Semipenetrans) and yield of mandarin trees in Egypt," *Acta Advances in Agricultural Sciences*, vol. 2, pp. 10-26, 2014.

[10] A. Cottenie, M. Verloo, L. Kiekens, G. Velghe, and R. Camrlynek, *Chemical analysis of plants and soils*. State Univ., Ghent Belgium, Hand Book, 1982.

[11] M. M. Alam, A. M. Khan, and S. K. Saxena, "Mechanism of control of plant-parasitic nematodes as a result of the application of organic amendments to the soil. V. Role of phenolic compounds," *Indian J. Nematol.*, vol. 4, pp. 93 – 96, 1979.

[12] A. Ismail and M. M. Mohamed, "Nematicidal potentiality of some animal manures combined with urea against meloidogyne arenaria and growth and productivity of sugar beet under field conditions," *J. of Nematology*, vol. 30, pp. 57-65, 2012.

[13] M. Alam, M. Ahmed, and A. Khan, "Effect of organic amendments on the growth and chemical composition of tomato, eggplant and chilli and their susceptibility to attack by Meloidogyne incognita," *Plant and Soil*, vol. 57, pp. 231-236, 1980.

[14] P. C. Trivedi and K. R. Barker, "Management of nematodes by cultural practices," *Nematropica*, vol. 16, pp. 213 – 236, 1986.

[15] W. R. Novaretti, J. O. Carderan, J. Starbelli, and E. Amorim, "Effect of compost application alone or in combination with nematicide and mineral fertilizers on nematode control and productivity of sugarcane," *Nematologia Brasileira*, vol. 13, pp. 93 – 107, 1989.

[16] G. R. Stirling, *Biological control of plant-parasitic nematodes*. Wallingford, UK: CAB Int, 1991.

[17] H. H. Hendy, H. I. El-Nagar, A. A. Osman, and A. A. Farahat, "The role of biological agents in regulating plant parasitic nematodes infecting tomato plants," *Egypt. J Appl. Sci.*, vol. 9, pp. 313 – 330, 1994.

[18] O. A. Egunjobi, "Effect of cocoa pod husks as soil amendments ob owpea, infestation by Meloidogyne sp," *Pak. J. Nematol.*, vol. 3, pp. 99 – 103, 1985.

[19] S. K. Abadir, A. E. Ismail, and A. M. Kheir, "Efficacy of soil amendments with plant waste in the control of meloidogyne incognita on sunflower," *Pak. J. Nematol.*, vol. 14, pp. 95-100, 1996.

[20] R. L. Cook and K. F. Baker, *The nature and practice of biological control of plant pathogens*. St. Paul, Minn: American Phytopathological Society, 1983.

[21] J. W. Waceke and S. W. Waudo, "Effect of soil amendments on pathogenicity of Meloidogyne incognita on okra," *Int. J. Pest Management*, vol. 39, pp. 385 – 389, 1993.

[22] H. Abd–El-Khair, W. M. A. El-Nagdi, O. M. Hafez, and H. H. Ameen, "Effect of four composts on meloidogyne incognita and fusarium solani infesting superior grapevine and their influence on yield production and quality," *Nematologia Mediterranea*, vol. 37, pp. 54–63, 2009.

[23] A. Ismail, "Effect of soil amendments with some hardwood barks on reproduction of rotylenchulus reniformis and growth of sunflower," *Pak. J. Nematol.*, vol. 16, pp. 137 – 144, 1998.

[24] A. E. Ismail, S. A. Mahouz, M. M. Mohamed, R. A. Hassan, and L. M. Abou-Setta, "Environmentally safe substances for controlling the root-knot nematode, meloidogyne arenaria infested potato and their influence on yield and alkaloidal content in Egypt," *Archives of Phytopathology and Plant Protection*, vol. 47, pp. 600 – 609, 2014.

[25] A. L. Saleh and A. Abd – Elfattah, "Response of nutrients uptake and dry weight of sorghum to application of FYM; poultry manure and their combination alone or with chemical fertilizers," *Egypt. J. Appl. Sci.*, vol. 12, pp. 217 – 228, 1997.

[26] A. E. Ismail and S. A. Hasabo, "Evaluation of some commercial biofertilizers, plant nutrients and a biocide against root-knot nematode, meloidogyne incognita infecting sunflower," *Pak. J. Nematol.*, vol. 18, pp. 39 – 49, 2000.

[27] A. E. Ismail, M. M. Abd-El-Migeed, R. A. Azza, and M. S. Awaad, "Meloidogyne incognita suppression and changes of grapevine yield properties determined by waste residues from jojoba, black seed oil extraction and slow release of nitrogen fertilizer," *Pak. J Nematol.*, vol. 29, pp. 187 – 205, 2011.

[28] S. A. Abolusoro, M. O. Abe, P. F. Abolusoro, and N. B. Lzuogu, "Control of nematode disease of eggplant (Solanum Aethiopicum) using manure," *Archives of Phytopathology and Plant Protection*, vol. 48, pp. 188-193, 2015.

Table-3. Effect of some composted plant or animal residues on growth of sunflower plant infected with *Meloidogyne javanica* (average of two seasons).

Substances	Dose % w/w	Shoot growth			Root growth		
		Weight (g)		Length (cm)	Weight (g)		Length (cm)
		Fresh	Dry		Fresh	Dry	
Banana tree (BT)	0.25	20.4 (0.0)	4.7 (62.1)	39.0 (12.4)	7.2 (10.8)	2.1 (0.0)	22.0 (0.0)
	0.5	21.3 (0.0)	5.4 (86.3)	42.0 (21.0)	7.3 (12.3)	2.3 (4.6)	23.5 (1.7)
	1.0	22.5 (0.0)	6.4 (120.7)	50.0 (44.1)	7.6 (16.9)	2.3 (4.6)	24.4 (5.6)
Maize stalks (MS)	0.25	28.5 (8.0)	4.0 (37.9)	43.0 (23.9)	8.2 (26.2)	2.3 (4.6)	23.5 (1.7)
	0.5	33.3 (26.1)	4.4 (51.7)	47.0 (35.4)	8.3 (27.7)	2.4 (9.1)	25.0 (8.2)
	1.0	34.6 (31.1)	4.5 (55.2)	66.0 (90.2)	9.3 (43.1)	3.2 (45.5)	27.3 (18.2)
Sawdust (SD)	0.25	32.1 (21.6)	4.7 (62.1)	40.0 (15.3)	8.3 (27.7)	2.1 (0.0)	22.0 (0.0)
	0.5	33.6 (27.3)	5.4 (86.3)	44.0 (26.8)	12.2 (87.7)	2.9 (31.8)	23.1 (4.3)
	1.0	40.4 (53.0)	6.4 (120.7)	49.0 (41.2)	13.4 (106.0)	3.2 (45.5)	28.1 (21.7)
Rice straw (RS)	0.25	27.3 (3.4)	2.9 (0.0)	43.0 (23.9)	8.5 (30.8)	2.4 (9.1)	25.0 (8.2)
	0.5	30.7 (16.3)	3.5 (20.7)	45.0 (29.7)	9.3 (43.1)	2.7 (22.7)	28.3 (22.5)
	1.0	48.5 (83.7)	7.0 (141.4)	56.0 (61.4)	15.2 (133.9)	3.9 (77.3)	30.0 (29.9)
Cattle dung (CD)	0.25	27.5 (4.2)	3.1 (6.9)	44.0 (26.8)	6.7 (3.1)	2.3 (4.6)	22.0 (0.0)
	0.5	30.5 (15.5)	3.7 (27.6)	44.0 (26.8)	7.3 (12.3)	2.4 (9.1)	23.5 (1.7)
	1.0	32.6 (23.5)	4.5 (55.2)	50.0 (44.1)	8.1 (24.6)	2.7 (22.7)	24.0 (3.9)
Control	-----	26.4	2.9	34.7	6.5	2.2	23.1
LSD 0.05		9.6	1.2	8.3	5.3	0.5	2.5
LSD 0.01		12.3	1.7	11.5	6.4	0.8	3.1

*Values between brackets indicate percentage increase compared to untreated control.

Table-4. Effect of some composted plant or animal residues on uptake of some macronutrients by soil or sunflower plants infected with *Meloidogyne javanica*

Substances	Dose % w/w	Shoot			Root			Soil	
		N%	P%	K%	N%	Organic carbon%	Organic matter%	E.C. mmhos /cm²	pH*
Banana tree (BT)	0.25	2.74	0.01	1.77	1.48	0.440	1.462	0.32	7.7
	0.5	2.74	0.01	4.64	1.72	0.447	0.758	0.39	8.0
	1.0	3.35	0.10	4.75	1.95	0.863	0.798	0.41	8.3
Maize stalks (MS)	0.25	2.60	0.01	3.61	1.59	0.402	0.694	0.21	8.3
	0.5	2.76	0.02	4.04	1.79	0.415	0.929	0.24	8.2
	1.0	3.66	0.02	4.93	1.88	0.539	0.716	0.32	7.9
Sawdust (SD)	0.25	2.65	0.02	1.37	1.60	0.323	0.559	0.37	7.3
	0.5	2.65	0.03	1.87	1.79	0.518	0.894	0.40	7.6
	1.0	3.00	0.04	4.04	1.99	0.708	1.220	0.50	7.7
Rice straw (RS)	0.25	3.40	0.10	2.50	1.59	0.360	0.622	0.36	7.8
	0.5	3.45	0.10	4.10	1.73	0.452	0.779	0.35	7.4
	1.0	3.58	0.13	5.48	1.91	1.147	1.978	0.40	7.5
Cattle dung (CD)	0.25	2.10	0.01	2.45	1.18	0.456	0.815	0.27	8.3
	0.5	2.43	0.01	4.49	1.36	0.472	0.787	0.26	8.2
	1.0	2.93	0.04	4.51	1.53	0.497	0.886	0.27	8.3
Control	-----	2.38	0.01	3.18	1.49	0.320	0.552	0.22	8.4

E.C. = Electrical conductivity. *pH = 1: 2.5 soil : water ratio

