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PJBS

ISSN 1028-8880

Pakistan Journal of Biological Sciences

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Pakistan Journal of Biological Sciences 5 (1): 32-35, 2002

Effect of Earthworm Activities (*Pheretema* sp.) on the Changes in Soil Chemical Properties at Different Soil Depths of Nampong Soil Series (Ustoxic Quartzipsamment) in Northeast Thailand

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Abstract: This field research was carried out at Udon Thani Province, Northeast Thailand with the use of Nampong soil series (Ustoxic Quartzipsamment) during 1998 to investigate the effect of earthworm (*Pheretema* sp.) activities on the changes in chemical properties of Nampong soil series at different soil depths in different eco-systems. Soil samples were taken once at the soil depth of 0-10, 10-20, 20-30 cm from locations with and without earthworm activities of the four eco-systems for the determinations of EC, pH, OM, available P, exchangeable K, Ca, and Mg. The results showed that earthworm activities, in most cases, have improved soil chemical properties at different depths in all locations studied and it was found that soil electrical conductivity (EC), organic matter (OM), available phosphorous (P), exchangeable potassium (K), calcium (Ca) and magnesium (Mg) values of tamarind orchard farm were much greater than those of other studied sites both with and without earthworm activities.

Key words: Earthworm casts, eco-system, *Pheretema,* soil chemical properties

Introduction

It has been stated that most soils in Northeast Thailand are the poor soil series due to deforestation causing high leaching and soil erosion and they have been used for growing many annual crop production for such a long time such as sugarcane, rice, cassava, maize, jute, and also other orchard plantations such as tamarind, citrus, lime etc. Northeast Thailand is a region located in a high land of Korat plateau of the country and most soils contained a large amount of sandy particles with low level of both soil pH and organic matter and also low level of soil fertility. These tremendously reflect the low margin of economic returns from the annual crop production. Growers of the region have been facing with many obstacles in producing cash crops for their annual income and living conditions. Soil deterioration in most agronomic areas in Northeast has been very severely found due to high leaching rate as a result of heavy tropical rainfalls and poor sandy soil structure (Polthanee, 1986 and Anonymous, 1998). Nevertheless, soil condition could be improved from time to time with simple technology such as the frequent additional amount of organic matter to the soils and liming to help improve soil properties. In nature, one way in improving soil condition could possibly be the activities of the many living organisms such as earthworms. Earthworms could possibly help in digesting decayed plant materials in soils mostly within the depth of 30 cm for their food and produce a number of earthworm casts. Furthermore, their movements in soil together with earthworm casts could possibly help in improving soil condition hence soil physical and chemical properties could possibly be improved as reported by Watanabe and Ruaysoongnern (1984), Lal (1987), and Chuasavathi *et al*. (2001). Therefore, the objective of this work was to collect the data derived from soil analysis among the four chosen sites at different soil depths of the soil environments, i.e., with and without earthworms with respect to the contribution of earthworm activities on the improvement of soil chemical properties.

Materials and Methods

This investigation was carried out during rainy season of 1998. Materials and methods being used were as that of the work reported by Chuasavathi *et al*. (2000 and 2001), i.e. the four chosen locations were dipterocarp forest, tamarind orchard farm, sugarcane plantation, and natural grazing pastureland areas of Udon Thani Province, Northeast Thailand. The areas with and without earthworm inhabitation were chosen for use with the application of grid method. The experimental design was a randomized complete design with four replications. Each plot had an area of 25 m^2. Soil samples of both with and without earthworms were collected once in August 1998 to the depths of 0-10, 10-20, and 20-30 cm. The collected soil samples were air-dried at room temperature and ground to pass through a 2 mm sieve and then the soil samples were used for the analysis of soil chemical properties. The analysis methods being used were: soil pH (1:1 soil:water by volume and 1:1 $CaCl_2$: soil, $CaCl_2$ solution 0.01M), electrical conductivity and organic matter percentage by Kjeldahl method (Black, 1965), whilst available P by Bray II (Drilon, 1980), exchangeable K, Ca, and Mg by Cottenie (1980). The collected data were statistically analyzed using MSTAT-C (Nissan, 1988).

Results and Discussion

Soil chemical properties of tamarind orchard farm: Soil analysis data of tamarind orchard farm with and without earthworms determined at three different depths evidently revealed that electrical conductivity (EC), pH, organic matter percentages (OM), available phosphorous, and exchangeable potassium (K), calcium (Ca) and magnesium (Mg) values were, in most cases, higher for soil with earthworms than that of the soil without and the differences were of statistical significance (Table 1). The results indicated that earthworm activities have had some contribution in improving chemical properties of the soil of tamarind orchard farm. However, the high pH values of the soil both with and without earthworms could possibly be due to the previous history of soil, where some amounts of lime, chemical fertilizers and organic materials had been added to the soil to improve soil condition for tamarind trees. Furthermore, the annual added amount of leaves of tamarind trees to the soil could also have partly improved the soil properties. The top layer of soil (0-20 cm depth) had attained a greater level of soil fertility than that of the further depth. The results suggested that the majority of living earthworms could have used the topsoil layer for their feeding and

Table 1: Soil chemical properties of tamarind plantation being analyzed from different replicated plots of earthworm activities and without earthworm activities

Sampling site	Depth (cm)	EC (µs/cm)	pH		O.M. (%)	Avai. P (ppm)	Exch. K (ppm)	Ca (ppm)	Mg (ppm)
			Water	$CaCl_2$					
With earthworm	0-10	96.67	6.50	5.87	1.02	67.73	132.6	512.0	139.2
Without earthworm	0-10	52.00	6.30	5.60	0.92	66.16	101.4	308.0	120.0
F-Test		**	NS	*	**	*	*	*	NS
C.V. (%)	1.45	1.91	1.30	1.26	0.30	4.13	14.64	31.46	
With earthworm	10-20	53.33	6.67	6.02	0.39	40.43	105.3	172.0	134.4
Without earthworm	10-20	61.33	6.07	5.33	0.45	35.47	93.6	136.0	64.8
F-Test		NS	*	NS	**	*	NS	*	*
C.V. (%)	6.17	1.96	3.96	1.94	3.73	6.62	3.14	18.96	
With earthworm	20-30	40.67	5.87	5.13	0.29	37.82	144.3	192.0	88.8
Without earthworm	20-30	29.33	6.07	5.23	0.27	17.50	89.7	84.0	48.0
F-Test		**	NS	NS	NS	**	**	NS	NS
C.V. (%)		2.33	2.77	1.58	6.36	3.11	2.75	16.37	20.55

*, ** indicate confidential limits at P = 0.05 and 0.01, respectively.

Table 2: Soil chemical properties of sugarcane plantation being analyzed from different replicated plots of earthworm activities and without earthworm activities.

Sampling site	Depth (cm)	EC (µs/cm)	pH		O.M. (%)	Avai. P (ppm)	Exch. K (ppm)	Ca (ppm)	Mg (ppm)
			Water	$CaCl_2$					
With earthworm	0-10	33.30	5.17	4.30	0.53	9.33	3.9	164.0	45.6
Without earthworm	0-10	29.23	5.37	4.40	0.45	34.80	15.6	76.0	21.6
F-Test		*	NS	NS	NS	**	*	*	*
C.V. (%)		3.46	1.34	1.63	26.10	6.79	15.31	16.91	15.62
With earthworm	10-20	30.30	5.23	4.25	0.45	8.67	15.6	164.0	33.6
Without earthworm	10-20	32.10	5.15	4.44	0.45	44.70	11.7	64.0	19.2
F-Test		NS	NS	NS	NS	**	*	*	NS
C.V. (%)		2.08	0.80	1.56	6.37	3.24	11.66	23.70	37.99
With earthworm	20-30	40.80	5.15	4.46	0.36	13.93	15.6	148.0	26.4
Without earthworm	20-30	23.37	5.18	4.62	0.35	33.47	11.7	64.0	16.8
F-Test		**	NS	NS	NS	**	NS	NS	NS
C.V. (%)		2.87	3.84	1.97	28.68	1.94	32.40	26.87	49.76

*, ** indicate confidential limits at P = 0.05 and 0.01, respectively.

Table 3: Soil chemical properties of dipterocarp forest being analyzed from different replicated plots of earthworm activities and without earthworm activities.

Sampling site	Depth (cm)	EC (µs/cm)	pH		O.M. (%)	Avai. P (ppm)	Exch. K (ppm)	Ca (ppm)	Mg (ppm)
			Water	$CaCl_2$					
With earthworm	0-10	57.47	5.82	5.16	0.72	2.66	70.2	256.0	84.0
Without earthworm	0-10	42.27	6.23	5.53	1.29	5.15	42.9	588.0	124.8
F-Test		**	NS	*	*	**	*	*	NS
C.V. (%)		3.16	2.37	1.65	14.42	2.35	12.47	11.65	16.16
With earthworm	10-20	35.40	6.26	4.88	0.35	1.35	54.6	180.0	62.4
Without earthworm	10-20	27.60	6.03	5.24	0.53	2.15	27.3	156.0	50.4
F-Test		*	NS	NS	NS	**	*	NS	NS
C.V. (%)		5.75	1.37	3.12	17.63	5.27	14.24	24.09	43.04
With earthworm	20-30	24.70	6.26	4.78	0.37	1.15	54.6	188.0	76.8
Without earthworm	20-30	27.67	6.15	5.23	0.37	1.91	23.4	148.0	45.6
F-Test		*	NS	**	NS	*	**	NS	*
C.V. (%)		2.57	1.03	1.02	29.39	9.05	8.45	16.30	7.43

*, ** Indicate confidential limits at P = 0.05 and 0.01, respectively.

inhabitation than that of the deeper soil layer particularly in rainy season, where favourable environmental conditions aided better growth condition for earthworms apart from high level of soil moisture content. Furthermore, there should have had some decayed plant materials available hence organic matter percentages were ranging from 0.29 to 1.02 for the deeper layer and top soil, respectively. The results agree with the work of Lal (1987) and Chuasavathi *et al.* (2001).

Soil chemical properties of sugarcane plantation: Soil pH and available P of soil with living earthworms, in most cases, were slightly lower than that of the soil without living earthworms whilst EC, OM, exchangeable K, Ca and Mg values, in most cases, were greater for the soil with earthworm activities. There were no statistical differences found with soil pH, EC, OM, exchangeable K, Ca and Mg whilst P did (Table 2). However, earthworm activities were mostly found with the area surrounded the sugarcane plots. This could presumably due to ploughing and the application of herbicide for the control of weeds before planting and also the burning of sugarcane residues before and after each harvest of sugarcane stalks that eliminated some number of living earthworms of the plots. The low values of soil nutrients in sugarcane plots must be attributed to the high annual amount of sugarcane production taken out of the land area, i.e. sugar cane plants must have taken a large quantity of soil nutrients for their growth and development hence the depletion of soil nutrients was taken place particularly the top soil layer where

Table 4: Soil chemical properties of grazing pasture being analyzed from different replicated plots of earthworm activities and without earthworm activities

Sampling site	Depth (cm)	EC (µs/cm)	pH Water	pH $CaCl_2$	O.M. (%)	Avai. P (ppm)	Exch. K (ppm)	Ca (ppm)	Mg (ppm)
With earthworm	0-10	48.77	4.83	4.06	0.54	9.57	19.5	92.0	19.2
Without earthworm	0-10	27.57	5.87	5.35	0.53	2.84	42.9	140.0	52.8
F-Test		**	**	**	NS	**	NS	NS	*
C.V. (%)		2.98	2.02	1.66	19.17	9.49	24.00	22.91	26.50
With earthworm	10-20	30.66	4.79	4.09	0.43	8.62	3.9	44.0	7.2
Without earthworm	10-20	27.23	6.06	5.21	0.35	3.84	46.8	76.0	36.0
F-Test		*	**	**	NS	**	*	NS	*
C.V. (%)		2.59	0.42	1.48	29.96	2.23	38.97	32.10	33.98
With earthworm	20-30	36.33	4.81	4.00	0.35	6.55	7.8	44.0	72.0
Without earthworm	20-30	24.53	6.13	4.07	0.27	1.76	50.7	64.0	24.0
F-Test		**	*	NS	NS	**	*	NS	*
C.V. (%)		0.80	3.19	2.58	32.46	1.21	31.00	22.83	28.78

*, ** Indicate confidential limits at P = 0.05 and 0.01, respectively

sugarcane plant roots had thrived on for more nutrients although some chemical fertilizers have been added annually to the soil. A large amount of calcium including nitrogen, potassium and other elements must have been taken out annually by sugarcane production resulting in the decrease in soil pH and the values attained from both methods of measurement were not suitable for the growth of many cash crops including sugar cane plants. Soil pH value of sugarcane plantation should reach the value of 6 (1:2.5 soil:water by volume) where many nutrients could possibly be released and available for the crop plants (Miller and Donahue, 1990; Suksri 1999). The high value of soil P found in all sugarcane plantation could possibly be due to the previous high rate of chemical fertilizer application and perhaps sugarcane plants had absorbed less amount of P since only lesser than 1 % is required for growth of the sugarcane plants and it was found that EC, OM, exchangeable K, Ca, and Mg of the area along the edge of the plots where earthworms had occupied were, in many cases, higher than the area inside without earthworm activities. The differences were of no statistical significance. The results suggested that earthworm activities improved the soil condition of the sugarcane plots, mostly found at the edge of the plots (Shakir *et al.,* 1997). However, growers must find some means and ways to attain more earthworms in most of the areas of the plots, i.e. soil and crop management programme must be applied and perhaps with less frequency of ploughing, and no burning of crop residues before and after the harvest of sugarcane production. Furthermore, herbicide and other toxic substances should not be applied to the plots.

Soil chemical properties of dipterocarp forest: Soil analysis data of the three different depths of dipterocarp forest revealed that earthworm activities have, in most cases, significantly improved soil chemical properties by increasing the values of electrical conductivity (EC), soil pH, exchangeable K, Ca, and Mg when compared with the data of soil without earthworm activities (Table 3). Organic matter percentages and available P, in most cases, were relatively low for those with earthworms compared with the soil without earthworms. The differences were of statistical significance. Nevertheless, the values of organic matter percentage and available P in all area being occupied by earthworms, it was found that this level of soil fertility could be considerably suitable for the survival of earthworms. This finding agrees with the work of Chuasavathi *et al.* (2000) and Chuasavathi *et al.* (2001). Furthermore, this dipterocarp forest has a diversity of plants covering ground areas, which could have some influential effects on the survival of earthworms, particularly the type of plant materials that could aid earthworm survival and other factors may have some effects on living earthworms such as light, temperature and soil moisture contents. These factors could possibly have some effects on the distribution of earthworms as suggested by Lal (1987), Shakir *et al.* (1997).

Soil chemical properties of natural grazing pasture: For natural grazing pasture, soil analysis data at different depths of soil showed that earthworm activities had improved soil fertility. Evidences were found with soil electrical conductivity values, organic matter, available P, i.e. in most cases their values were significantly greater for those with earthworm activities than those without (Table 4). This may be attributed to the effect of no tillage of this land area where earthworms did not receive disturbances from ploughing including the disturbance being made by toxic chemical substances so that the grasses remain green all over the year hence earthworms were evenly distributed with high density and it was found that this inhabitation had the highest amount of earthworms compared with other eco-systems (Chuasavathi *et al.,* 2000). However, a reverse result was found with soil pH, exchangeable K, Ca, and Mg, i.e. their values were, in most cases, lesser for those with earthworm activities than those without and the differences were significant statistically. Another reason could have been due to the high leaching rate of soil nutrients due to earthworm activities, i.e. their activities must have created more aeration pores than other eco-systems hence soil pH values and nutrient level were lower than those without earthworm activities and it may be possible that some soluble amount of Ca, Mg, and exchangeable K had been leaching out to deeper depths by heavy rainfalls due to high level of porosity and earthworm activities could have aided more leaching rate as stated by Hillel (1990).

To sum up, soil chemical analysis at different soil depths of the four different eco-systems of earthworm inhabitation, i.e. tamarind orchard farm, sugarcane plantation, dipterocarp forest, and natural grazing pasture, the results evidently showed that earthworm activities, in most cases, had improved soil chemical properties by their activities at different depths of soil when compared with the land areas without earthworm activities. Earthworm activities were highest with tamarind orchard farm whilst other eco-systems tested were similar. The majority of sites of earthworm inhabitation were found mostly in the eco-systems where less frequency of disturbances and with no application of insecticides and herbicides along with an adequate amount of feeding stuff and other favourable factors for living earthworms. Earthworms should be available in most agricultural soils.

Acknowledgments

The authors wish to thank the Commission of National Research Council of Thailand for financial supports, the Faculty of Agriculture, Khon Kaen University for some facilities provided.

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