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Earthworm Casts (*Pheretema* sp.) Nutrient Contents of Nampong Soil Series (Ustoxic Quartzipsamment) in Northeast Thailand

T. Chuasavathi, V. Trelo-ges and S. Ruaysoongnern
Department of Land Resources and Environment, Faculty of Agriculture,
Khon Kaen University, Khon Kaen 40002, Thailand

Abstract: This earthworm cast experiment was carried out at four different sites of Nampong soil series (Ustoxic quartzipsamment) namely dipterocarp forest, tamarind orchard farm, grazing pasture, and sugarcane plantation.
The results showed that earthworm casts of the four locations contented different levels of nutrients. The highest nutrient contents were found with Tamarind orchard farm followed by Dipterocarp forest, grazing pasture, and sugarcane plantation, respectively. Data on nutrient contents (NPK, Ca, Mg, and Na) of earthworm casts of each location were much higher than that of their respective soils. Earthworm casts could help to improve soil properties particularly Nampong soil series, which contented low level of soil fertility. This may help to improve crop yield for sustainable agriculture.

Key words: Earthworm casts, *Pheretema*, soil fertility, tamarind orchard, sugarcane, grazing pasture, dipterocarp forest

Introduction

Amongst the various major soil types in Northeast Thailand, Nampong soil series (Ustoxic quartzipsamment) has been considered as one of the poorest soil types for agricultural activities in the region. With this soil type, soil erosion and leaching could take place very severely due to sandy particles when monsoon comes (Anonymous, 1998). This soil type contented the majority of sand particles particularly top layer with extremely low amount of organic matter and available nutrients. Hence it is difficult for growers to obtain high out puts from this type of agricultural land area without adding high in puts to the farms. It has been observed during past decades that most of the growers who own pieces of lands with this soil type seek income from their lands with minimum inputs so their margins of profits were relatively low (Ruaysoongnern and Chuasavathi, 1996). It is of imperative value to improve this sort of land in order to make its fertility reaching a considerable level where a number of cash crops could thrive on with high annual out puts so that their income and quality of life of the growers could be improved. The improvement of soil fertility as reported by Chuasavathi and Trelo-ges (2001) with the use of municipal organic compost could be one way in improving soil fertility, apart from this some contributions derive from earthworms may be of tangible value, i.e. the presence of earthworms in soil could possibly help a lot in improving soil conditions and its fertility (Chuasavathi *et al*., 2000). The amount of earthworm casts found in any pieces of lands could possibly indicate certain level of soil fertility since earthworms normally feed more or less on soil organic matter or the decayed plant materials contented nutritious values for their normal growth and development. Earthworm activities could possibly lead to the establishment of better environment for crop growth, e.g., aeration of soil environment, which could be facilitated well by the movement of earthworms in soil. Lal (1987) reported that earthworm casts contented some amounts of organic matter and nutrients useful for the growth of crop plants, whilst Watanabe and Ruaysoongnern (1984) showed that earthworms (*Pheretema* sp.), those found in Northeast Thailand soils produced a large size of worm casts. It has 35 cm in length with 5 cm diameter and the whole cast weighed up to 975 g. However, in general, most earthworm casts of *Pheretema* sp. normally possess the length within the range of 10-20 cm with the weights between 100-400 g. They could produce an average amount of worm casts up to 224.9 t/ha annually. Therefore, in terms of environmental context for crop growth, earthworms could have contributed some tangible value in improving soil environments for high out put of crop production for most crop plants apart from other contributable factors such as radiant energy, chemical nutrients, water and others. Most of earthworm casts contented higher level of nutrients than that of their habitable soils. Hence, it is of significant value to investigate how earthworm casts could be valued with respect to the amount of cast nutrient contents in relation to various environmental conditions being used for crop production, particularly with poor soils.

Materials and Methods

The experiment was carried out at Kumpawapee District, Udonthani Province, Thailand. The four different sites of land areas being chosen were native dipterocarp forest, tamarind orchard, natural grazing areas and sugarcane plantation. These four locations were used as treatments. The experiment was laid in a randomized complete block design with four replications. The plot size for each replication has the area of 25 m^2 and the initial soil samples were taken at random to the depth of approximately 30 cm for the determinations of soil pH, electrical conductivity, total nitrogen contents, soil available phosphorous, exchangeable potassium, calcium, magnesium and sodium. Earthworm casts were taken at monthly interval for five times from July to November 1998 for the laboratory analysis as done with those of the initial soil samples. Soil pH (1:1 soil: water), electrical conductivity, organic matter percentage, and nitrogen percentages (Kjeldahl method) were carried out by the methods of Black (1965) whilst available phosphorous (P) was done with Bray II of Drilon (1980). The determinations of exchangeable potassium (K), calcium (Ca), magnesium (Mg) and sodium (Na) were carried out by the methods of Cottenie (1980). The attained data were statistically analyzed using MSTAT-C computer programme of Nissan (1988).

Results and Discussion

The results from initial soil analysis data of the four different locations indicated that soil nitrogen percentages, available phosphorous, exchangeable potassium, calcium, magnesium, and sodium varied largely among the four locations (Table 1). Dipterocarp forest contented the highest value of N % while available phosphorous and exchangeable potassium values were highest for those of tamarind orchard farm and the other elements were more or less similar. The results indicated that soil available P were very much deficient in most locations except that of tamarind orchard farm. The results

Table 1: Mean values of nitrogen percentages (N), available phosphorous (P), exchangeable potassium (K), magnesium (Mg), and sodium (Na) of top layer of Nampong soil series (Ustoxic quartzipsamment) being taken from dipterocarp forest, tamarind orchard, grazing pasture, and sugarcane plantation where earthworms (Pheretema sp.) have inhabited, Northeast Thailand.

Experimental sites	N (%)	P (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)	Na (Ppm)
Dipt. forest	0.04	5.00	69.93	163.41	34.19	14.92
Tam. orchard	0.02	65.17	133.00	148.55	48.92	14.20
Graz. pasture	0.03	10.67	28.27	95.07	13.95	15.10
Sugarcane plant.	0.02	15.83	49.09	114.37	14.83	14.83

Table 2: Means of pH values of earthworm casts from July to November 1998. Being taken at monthly interval from dipterocarp forest, tamarind orchard, grazing pasture, and sugarcane plantation of Nampong soil series (Ustoxic quartzipsamment) where earthworms have inhabited.

Experimental sites	Sampling periods (months)					F-test	C.V.(%)
	Jul.	Aug.	Sep.	Oct.	Nov.		
Dipt. forest	5.92 Bb	6.10 Ba	5.65 Bd	5.76 Bc	5.90 Bb	**	0.64
Tam. orchard	6.54 Aa	6.38 Ac	6.32 Ad	6.31 Ad	6.48 Ab	**	0.44
Graz. pasture	5.53 Cb	5.33 Dc	4.83 Dd	5.35 Cc	5.61 Da	**	0.52
Sugarcane plant.	5.14 Dd	5.55 Cb	5.27 Cc	5.24 Dc	5.83 Ca	**	0.46
F-test	**	**	**	**	**		
C.V. (%)	0.36	0.65	0.64	0.47	0.47		

*,** Indicate confidential limits at P = 0.05 and 0.01, respectively. Capital letters indicate Duncan's Multiple Range Test of vertical rows while the italic ones represent the horizontal rows.

Table 3: Average soil conductivity values (μMho/cm) of earthworm casts (Pheretema sp.) being taken at monthly interval from dipterocarp forest, tamarind orchard, grazing pasture, and sugarcane plantation during July to November, 1998 of Nampong soil series (Ustoxic quartzipsamment) in Northeast Thailand.

Experimental sites	Sampling periods (months)					F-test	C.V.(%)
	Jul.	Aug.	Sep.	Oct.	Nov.		
Dipt. forest	89.2 Be	113.0 Bd	156.4 Bb	177.7Ba	130.0Bc	**	1.84
Tam. orchard	184.6Ad	277.1 Ab	361.6 Aa	189.8Ac	160.1Ae	**	1.16
Graz. pasture	83.3 Cd	115.2 Bb	107.6 Cc	83.2 Cd	120.9Ca	**	1.74
Sugarcane plant.	66.7 Dc	87.1 Ca	77.1 Db	45.3 Dd	88.4 Da	**	1.56
F-test	**	**	**	**	**		
C.V. (%)	2.13	1.77	0.94	1.81	0.98		

*,** Indicate confidential limits at P = 0.05 and 0.01, respectively. Capital letters indicate Duncan's Multiple Range Test of vertical rows while the italic ones represent the horizontal rows.

Table 4: Average values of organic matter percentages of earthworm casts of Pheretema sp. being taken at monthly interval from dipterocarp forest, tamarind orchard, grazing pasture, and sugarcane plantation during July to November 1998 of Nampong soil series (Ustoxic quartzipsamment), Northeast Thailand.

Experimental	Sampling periods (months)					F-test	C.V. (%)
	Jul.	Aug.	Sep.	Oct.	Nov.		
Dipt. forest	1.86 Cc	2.25 Ba	1.98 Bb	1.68 Cd	1.39 Be	**	1.71
Tam. orchard	3.32 Aa	2.98 Ab	2.64 Ac	2.30 Ad	1.40 Be	**	0.99
Graz. pasture	2.11 Ba	2.00 Cb	1.77 Cc	2.06 Ba	1.75 Ac	**	1.63
Sugarcane plant.	1.87 Cb	2.03 Ca	1.46 Dc	1.14 De	1.37 Bd	**	1.99
F-test	**	**	**	**	**		
C.V. (%)	1.40	1.64	2.07	2.24	2.75		

*,** Indicate confidential limits at P = 0.05 and 0.01, respectively. Capital letters indicate Duncan's Multiple Range Test of vertical rows while the italic ones represent the horizontal rows.

Table 5: Average values of nitrogen percentages of earthworm casts of Pheretema sp. being taken at monthly interval from dipterocarp forest, tamarind orchard, grazing pasture, and sugarcane plantation during July to November 1998 of Nampong soil series (Ustoxic quartzipsamment), Northeast Thailand.

Experimental sites	Sampling periods (months)					F-test	C.V. (%)
	Jul.	Aug.	Sep.	Oct.	Nov.		
Dipt. forest	0.069 Cc	0.110 Ba	0.107 Ba	0.071 Cb	0.060 Cc	**	3.48
Tam. orchard	0.153 Aa	0.134 Ab	0.156 Aa	0.114 Ac	0.071Ad	**	1.63
Graz. pasture	0.081 Ba	0.085 Ca	0.076 Cb	0.082 Ba	0.062 Bc	**	3.31
F-test	**	**	**	**	**		
C.V. (%)	3.62	3.99	1.97	1.72	3.42		

*,** Indicate confidential limits at P = 0.05 and 0.01, respectively. Capital letters indicate Duncan's Multiple Range Test of vertical rows while the italic ones represent the horizontal rows.

tremendously signify the poor soil fertility of Nampong soil series (Ustoxic quartzipsamment) except that of the tamarind orchard farm where some large amounts of chemical fertilizers, dolomite, and cattle manure may have been added to the soil for tamarind fruit production. Therefore, to attain some considerable amount of crop production annually from this soil series some large amounts of chemical fertilizers and organic matter must be applied. There has been a similar trend on soil pH of earthworm casts to that of soil nutrient contents, i.e. the highest value of soil pH value was found with tamarind orchard farm (Table 2). Soil pH values of tamarind orchard farm could be considered as a suitable soil pH range for the

Table 6: Average values of available phosphorous (ppm) of earthworm casts of Pheretema sp. being taken at monthly interval from dipterocarp forest, tamarind orchard, grazing pasture, and sugarcane plantation during July to November 1998 of Nampong soil series (Ustoxic quartzipsamment), Northeast Thailand.

Experimental sites	Sampling periods (months)					F-test	C.V. (%)
	Jul.	Aug.	Sep.	Oct.	Nov.		
Dipt. forest	6.57 Cd	36.65 Ba	17.89Db	9.46 Cc	10.10 Dc	**	7.69
Tam. orchard	134.23 Ab	151.21 Aa	147.91Aa	152.20 Aa	123.32 Ac	**	2.99
Graz. pasture	19.99 B	22.99 C	22.06 C	20.85 B	20.39 C	NS	8.41
F-test	**	**	**	**	**		
	5.77	4.62	2.53	5.13	6.04		

*,** Indicate confidential limits at P = 0.05 and 0.01, respectively. Capital letters indicate Duncan's Multiple Range Test of vertical rows while the italic ones represent the horizontal rows.

Table 7: Average values of exchangeable potassium (ppm) of earthworm casts of Pheretema sp. being taken at monthly interval from dipterocarp forest, tamarind orchard, grazing pasture, and sugarcane plantation during July to November 1998 of Nampong soil series (Ustoxic quartzipsamment), Northeast Thailand.

Experimental sites	Sampling periods (months)					F-test	C.V. (%)
	Jul.	Aug.	Sep.	Oct.	Nov.		
Dipt. forest	82.0 Be	124.1 Bc	97.8 Bd	159.7 Ba	130.6 Bb	**	0.64
Tam. orchard	158.8 Ae	340.2 Aa	226.8 Ac	216.6 Ad	231.4 Ab	**	0.69
Graz. pasture	35.7 Dd	24.0 De	83.0 Ca	38.2 Dc	44.3 Db	**	2.82
Sugarcane Plant.	52.8 Cb	39.8 Cc	50.0 Db	51.8 Cb	56.1 Ca	**	2.95
F-test	**	**	**	**	**		
C.V. (%)	1.63	1.25	1.26	1.19	1.01		

*,** Indicate confidential limits at P = 0.05 and 0.01, respectively. Capital letters indicate Duncan's Multiple Range Test of vertical rows while the italic ones represent the horizontal rows.

Table 8: Average values of calcium (ppm) of earthworm casts of Pheretema sp. being taken at monthly interval from dipterocarp forest, tamarind orchard, grazing pasture, and sugarcane plantation during July to November 1998 of Nampong soil series (Ustoxic quartzipsamment), Northeast Thailand.

Experimental sites	Sampling periods (months)					F-test	C.V. (%)
	Jul.	Aug.	Sep.	Oct.	Nov.		
Dipt. forest	394.6 Bd	873.8 Ba	644.5 Bb	449.7 Bc	299.3 Be	**	0.22
Tam. orchard	1292.2 Ab	1063.0 Ac	1562.8 Aa	624.2 Ad	351.6 Ae	**	0.18
Graz. pasture	379.7 Ca	342.1 Cb	310.6 Cc	251.1 Cd	225.4 Ce	**	0.23
F-test	**	**	**	**	**		
C.V. (%)	0.32	0.27	0.25	0.62	0.90		

*,** Indicate confidential limits at P = 0.05 and 0.01, respectively. Capital letters indicate Duncan's Multiple Range Test of vertical rows while the italic ones represent the horizontal rows.

Table 9: Average values of magnesium (ppm) of earthworm casts of Pheretema sp being taken at monthly interval from dipterocarp forest, tamarind orchard, grazing pasture, and sugarcane plantation during July to November 1998 of Nampong soil series (Ustoxic quartzipsamment), Northeast Thailand.

Experimental sites	Sampling periods (months)					F-test	C.V. (%)
	Jul.	Aug.	Sep.	Oct.	Nov.		
Dipt. forest	102.7 Bd	169.1 Ba	144.8 Bb	113.3Bc	102.7Bd	**	1.01
Tam. orchard	366.7 Aa	265.9 Ac	301.7 Ab	233.8Ad	152.8Ae	**	3.03
Graz. pasture	71.0 Cc	62.7 Dd	107.0 Ca	89.9 Cb	71.2 Dc	**	1.74
F-test	**	**	**	**	**		
C.V. (%)	1.02	6.13	0.30	1.01	1.20		

*,** Indicate confidential limits at P = 0.05 and 0.01, respectively. Capital letters indicate Duncan's Multiple Range Test of vertical rows while the italic ones represent the horizontal rows.

Table 10: Average values of sodium (ppm) of earthworm casts of Pheretema sp being taken at monthly interval from dipterocarp forest, tamarind orchard, grazing pasture, and sugarcane plantation during July to November 1998 of Nampong soil series (Ustoxic quartzipsamment), Northeast Thailand.

Experimental sites	Sampling periods (months)					F-test	C.V. (%)
	Jul.	Aug.	Sep.	Oct.	Nov.		
Dipt. forest	42.0 Db	44.9 Aa	40.9 Cb	45.1 Ca	37.0 Dc	**	3.37
Tam. orchard	58.9 Ba	39.4 Bc	45.8 Bb	48.2 Bb	57.6 Ca	**	3.03
Graz. pasture	54.2 Cb	40.7 Bd	52.2 Ab	45.1 Cc	79.5 Aa	**	3.07
Sugarcane plant.	70.5 Aa	36.2 Cd	47.8 Bc	56.6 Ab	69.1 Ba	**	2.77
F-test	**	**	**	**	**		
C.V. (%)	2.69	2.30	2.62	2.39	2.93		

*,** Indicate confidential limits at P = 0.05 and 0.01, respectively. Capital letters indicate Duncan's Multiple Range Test of vertical rows while the italic ones represent the horizontal rows.

growth of crop plants whilst the rest seem to possess acidic conditions since the attained values were below the value of 6 as stated by Miller and Donahue (1990), Suksri (1999). Similarly, the data on soil electrical conductivities of earthworm casts indicated that tamarind orchard farm had the highest values whilst the rest had much lower values (Table 3). With organic matter percentages of earthworm casts within the range of five months, the results showed that

earthworm casts collected from tamarind orchard farm had the mean values of 1.40-3.32 % followed by grazing pasture land (1.75-2.11 %), dipterocarp forest (1.39-2.25 %) and the least was for that of sugarcane plantation, which ranged from 1.14-2.03 % (Table 4). These values were much higher than their habitable soil (Chuasavathi *et al.*, 2000). The results suggested that tamarind orchard soil could have contented higher percentages of organic matter than the rest due to the annual additional amounts of cattle manure and the fallen leaves of tamarind trees together with some weed plant materials. Soil organic matter percentages in all treated soils decline with time to the final sampling period. The decline in soil organic matter percentages could possibly be attributed to the rapid decomposition rate of soil organic matter due to high environmental temperature as reported by Ratnapradipa (1996), Chuasavathi and Trelo-ges (2001). Organic matter percentage contents of earthworm casts could possibly be used to indicate soil fertility level. The high values of organic matter percentages of earthworm casts in all treated locations could possibly be due to intake of decomposed cattle manure, humus and plant materials in soil by earthworms, which could have been selectively taken up by this type of animal. Hence, earthworms could have some contributions on NPK nutrients to soil fertility in this way. A similar trend was found with earthworm casts on NPK contents, i.e. earthworm casts collected from soil of tamarind orchard farm had the highest values of NPK in all sampling periods as compared with the rest (Tables 5,6,7). The differences were large and statistically significant. The results indicated that earthworm cast residue contents of NPK have followed soil fertility level, which was highest with that of tamarind orchard farm. One aspect to observe about is the amount of plant residues being gathered within the vicinity of the farm, i.e. apart from some certain amount of cattle manure, chemical fertilizer and dolomite added to the soil together with some amounts of aging leaves of tamarind plants that have fallen down to the ground and then being decomposed to form humus for earthworms to consume, hence, higher nutrient level than that of the rest could be detected. Therefore, a better environment for earthworms should have been managed under a particular soil fertility programme suitable to type of crops being grown. Another reason for this could also be attributed to the previous history of soils where some amounts of chemical fertilizer have been added, particularly that of tamarind orchard farm apart from natural gathering of plant materials over the ground areas. For the case of dipterocarp forest, this type of forest has a diversity of plants being grown together, while that of natural grazing pasture has more or less only grass species. Therefore, dipterocarp forest should gain more organic materials added to the soil than the rest but perhaps not with the case of sugarcane plantation soil where some large amounts of sugarcane plants have been taken out to sugar mills although some amounts of chemical fertilizers have been added annually. Furthermore, sugarcane plantation had been ploughed annually while dipterocarp and natural grazing pasture did not. The results on nutrient contents of earthworm casts, which had contented higher level of nutrients than that of their respective soils in all studied sites evidently signified the significant role of earthworms in improving both soil fertility and soil condition.

With earthworm casts on calcium contents, the results showed that the amounts of Ca, in most sampling periods, were highest for tamarind orchard farm (Table 8). Again, earthworm cast Ca contents had followed the same pattern as that of nutrient contents. The amount of calcium contents in both soil and earthworm casts could possibly indicate how soil environment facilitates the available amount of soil nutrients, i.e. the higher the amount of Ca the better the soil condition. A similar time trend was also found with magnesium contents where the sequential levels of Mg were highest for tamarind orchard farm (Table 9). On the contrary, earthworm casts of the four sites did not follow the same pattern as that of nutrient contents. They had different levels of sodium contents and the initial value was highest with that of sugarcane plantation (Table 10). The distribution of sodium salt among the four environments could possibly be depended on underground salt and capillary water from rains. Therefore, the amounts presented in earthworm casts were somewhat inconsistently found. The results indicate the deposited amount of underground sodium, which may later produce some harmful toxicity of chloride (Cl^-) to crop plants when the concentration is relatively high (Mengel and Kirkby, 1987; Miller and Donahue, 1990 and Suksri, 1999).

To sum up, earthworm casts of the four locations contented different levels of nutrients. The highest nutrient contents of earthworm casts were found with tamarind orchard farm followed by dipterocarp forest, grazing pasture, and sugarcane plantation, respectively. Nutrient contents in earthworm casts were much greater than that of their respective soils in each location. Nutrient contents of earthworm casts could be used as an indicator to confirm soil fertility level, improvement of soil fertility and soil environment. Therefore, it is an imperative value for growers to improve their soil conditions with the use of earthworms apart from other organic materials and chemical fertilizers and scientists should have more data about them. Nampong soil series could be recognized as a relatively poor soil series being used for the cultivation of cash crop plants.

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