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Evaluation of nutrient status in termite mounds and adjacent soils associated with tasar sericulture ecosystem

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Abstract
This study was conducted to evaluate the nutrient status of termite mound soil in comparison to the adjacent soil collected from various tasar host plants growing areas of Jharkhand. The parameters studied are soil pH, organic carbon, macro and micronutrients. Standard procedures were used to analyse the soil chemical properties. Results revealed that termites' activity induced significant chemical changes in the mound soil than the adjacent soils. Interestingly, termite activity didn't affect the soil pH. Organic carbon content is significantly higher in mounds than the surrounding soils. Available phosphorus (P) content was found to be lower in the termite mound than in the adjacent soil. In contrast, significant micronutrient enrichment was observed for available Iron (Fe), Manganese (Mn), Zinc (Zn) and Copper (Cu) in the termite mound soils. These findings suggest that the mounds of termites, along with being enriched with phosphorus nutrients can be used to amend the micronutrient deficient soils. Termite soils can also be incorporated in Integrated Nutrient Management package for organic tasar silk production.

Keywords: Soil pH, organic carbon, Phosphorous, micronutrients, organic carbon

Introduction

Tropical Tasar silkworm *Antheraea mylitta* Drury is a polyphagous insect feeding primarily on Asan (*Terminalia tomentosa*), Arjun (*T. arjuna*), Sal (*Shorea robusta)* and secondarily on more than two dozen of food plants. About 70 % of the tasar production is from Jharkhand. So, Jharkhand is regarded as the tasar capital of India. The tasar silk quality and quantity depend upon nutritional value of their food plants [1]. Further, the quality of tasar food plant leaves depend on the nutritional status of the soil. Quality of leaves depends on the soil fertility and balanced supply of essential nutrients from soil [2]. The tasar food plants are often, growing in grave nutrient stress environments. Majority of the tasar farmers are continuously neglecting to apply both organic and inorganic nutrients to food plants growing soils. Tasar food plants obtain nutrients naturally through various sources *viz.* silkworm litters, decomposition of organic matter by termites, fungi, other arthropods etc. Among them, termite plays vital role in transformation of organic matter and availability of nutrients to the tasar food plants. In major part of the tasar growing areas, both mound building and mound less termites are abundant and widely distributed (Baig, Unpublished).

Termites are the most important soil fauna in the semi-arid tropics [3], they are often regarded as pests because they attack food crops and households [4]. As a result, much of the research is diverted towards its management over-looking its ecosystem services. From an ecological point of view, termite mounds are nutrient hotspots [5-7]. Termite mounds are conspicuous features of tasar ecosystem of Jharkhand. Termites are recognized as "ecosystem engineers" because they encourage soil transformation by disturbance processes [8]. They bring the material from diverse soil depths and deposit them in mounds, so that the physico-chemical and biological properties are higher in termite mounds than in the adjacent soils [9]. African subsistence farmers, follow the practice of spreading termite mound materials in their fields to enhance soil physico-chemical properties [10]. This practice is still practiced by Indian farmers at some pockets of the country. Tasar growing regions and particularly in the study areas, the impact of mound-building termites on soil ecology in general and soil chemical properties in particular were not yet studied. The aim of the study was to examine the soil nutrient distribution in termite mounds in relation to adjacent soil in Ranchi and Chaibasa areas of Jharkhand.

2. Materials and methods

2.1 Study area

The study was conducted at the Central Tasar Research and Training Institute (CTR&TI), Ranchi, Jharkhand, India (23.3250° N, 85.1615° E). The soil samples from mound and adjacent soils are collected from field laboratory of CTRTI; Namkum (23.3324° N, 85.3808° E) & Chaibasa (22.5474° N, 85.8025° E), Jharkhand. The study sites were selected because of widespread termite mounds in these tasar culture predominant areas. The soil is well-drained & red in colour.

2.2 Sample collection

Termite mounds are destroyed and from each mound, a composite sample (pooled soil from different parts of mound, both external and internal) was collected with an auger. At 2.0m away from the mound, control composite soil (top 15-25 cm) sample was taken. Termite mound and adjacent soils were collected from a uniform slope to reduce the variations that arise due to topographic effects like leaching of nutrients from the mound to adjacent soils. In order to evaluate some soil chemical properties of termite mounds in relation to the surrounding soils, a total of two hundred soil samples, hundred in each mound and surroundings soils were sampled for this study. Termites were collected from each mound and preserved in 80% alcohol for identification.

2.3 Chemical analysis of termite mound and adjacent soils

The soil samples were air dried, ground, mixed well and passed through a 2 mm sieve for analysis. Soil pH was measured using pH-meter in a 1:2.5 soil water ratio [11]. Determination of organic carbon content was carried out following the Walkley and Black wet digestion procedure [12]. Available phosphorus analysis was undertaken according to the method described by Bray and Kurtz [13]. Micronutrients, i.e., Copper (Cu), Manganese (Mn), Iron (Fe), and Zinc (Zn), were leached with DTPA extractant and their concentrations in leachates were determined by atomic adsorption spectroscopy (FS-280, Agilent Co., USA). The data was analyzed for its descriptive statistics.

3. Results and Discussion

A total of 9 species belonging to 2 genera were identified in the study areas (Table 1). All the species belong to Termitidae family.

Table 1: Termite species collected from different tasar growing areas

S. No	Termite species
1	*Odentotermes adumpurensis*
2	*O. ganpati*
3	*O. obesus*
4	*O. vaishno*
5	*O. redemanni*
6	*Pseudocapritermes fletcheri*
7	*O. proformosanus*
8	*O. parvidense*
9	*O. latiguloides*

3.1 Soil pH

The pH of termite mound soils was not significantly different in relation to the adjacent control soil for all the places studied (Table 2). The pH range of mound soil was 5.2-6.9 and for adjacent soils was 4.9-7.2.

3.2 Soil Organic carbon and Available Phosphorous

Soil organic carbon was more in mound soils of the studied termite species Organic carbon in mound ranges from 0.5-0.7 % (Table 2). When the termite mound soil was compared with surface soil of the surrounding soils, the available 'P' content of the termite mound was significantly lower compared to the surrounding soils except in the case of *Odontotermes parvidense* i.e. 44.5 kg/ha (Table 2).

Table 2: Soil pH, organic carbon (%) and available phosphorus content (kg ha^{-1}) in mound structures and surrounding soils of different termite species

S. No	Termite species	Soil sample	pH (μ±SE)	Organic Carbon	Phosphorus
1	*Odentotermes adumpurensis*	Mound	5.5 ± 0.04	0.6 ± 0.05	5.2 ± 0.10
		Surrounding	4.9 ± 0.01	0.5 ± 0.01	11.9 ± 0.25
2	*O. ganpati*	Mound	5.6 ± 0.15	0.7 ± 0.04	8.1 ± 0.80
		Surrounding	6.2 ± 0.20	0.3 ± 0.01	17.6 ± 0.50
3	*O. obesus*	Mound	6.8 ± 0.10	0.7± 0.20	7.9 ± 0.20
		Surrounding	6. 6± 0.14	0.5 ± 0.01	14.0 ± 0.22
4	*O. vaishno*	Mound	6.4 ± 0.04	0.5 ± 0.04	5.0 ± 0.10
		Surrounding	5.5 ± 0.13	0.3 ± 0.02	11.9 ± 0.60
5	*O. redemanni*	Mound	5.2 ± 0.10	0.6 ± 0.10	5.5 ± 0.10
		Surrounding	5.6 ± 0.12	0.4 ± 0.02	14.3 ± 0.50
6	*Pseudocapritermes fletcheri*	Mound	5.6 ± 0.06	0.7 ± 0.04	3.6 ± 0.10
		Surrounding	5.5 ± 0.15	0.6 ± 0.01	9.2 ± 0.20
7	*O. proformosanus*	Mound	5.2 ± 0.10	0.7 ± 0.02	6.2 ± 0.60
		Surrounding	6.4 ± 0.07	0.5 ± 0.01	16.9 ± 0.40
8	*O. parvidense*	Mound	6.9 ± 0.10	0.7 ± 0.10	44.5 ± 0.70
		Surrounding	7.0 ± 0.010	0.5 ± 0.20	31.9 ± 0.10
9	*O. latiguloides*	Mound	6.7 ± 0.10	0.6 ± 0.10	7.4 ± 0.10
		Surrounding	7.2 ± 0.10	0.4 ± 0.02	13.4 ± 0.40

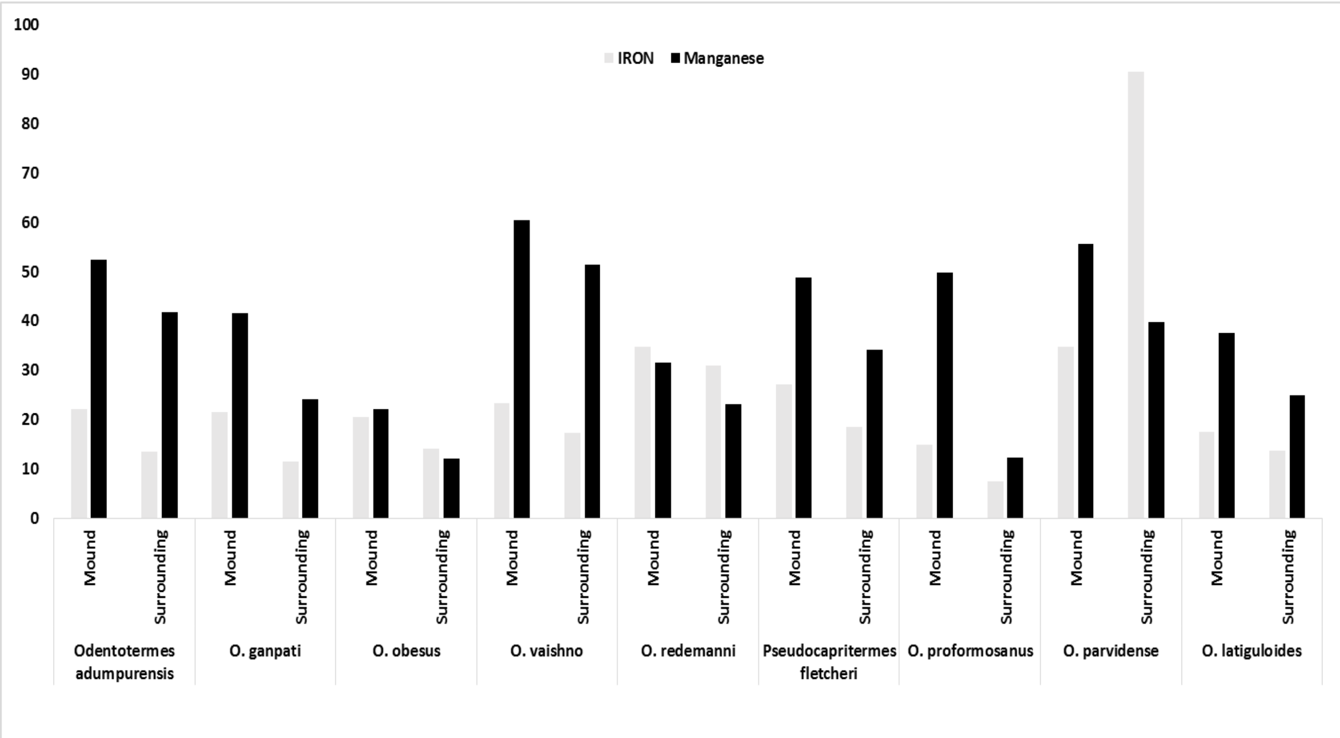
3.3 Micronutrients

The different identified termite mound soils had appreciably higher available micronutrients (mg kg^{-1} soil) i.e. Fe, Mn, Zn and Cu in relation to surrounding soil at all the study sites (Table 3). Available 'Fe' content is highest in *O. parvidense & O. redemanni* (34.8 mg/kg soil). However, termite *O. parvidense* mound soil showed lower available 'Fe' content which is almost three times lesser than surrounding soil

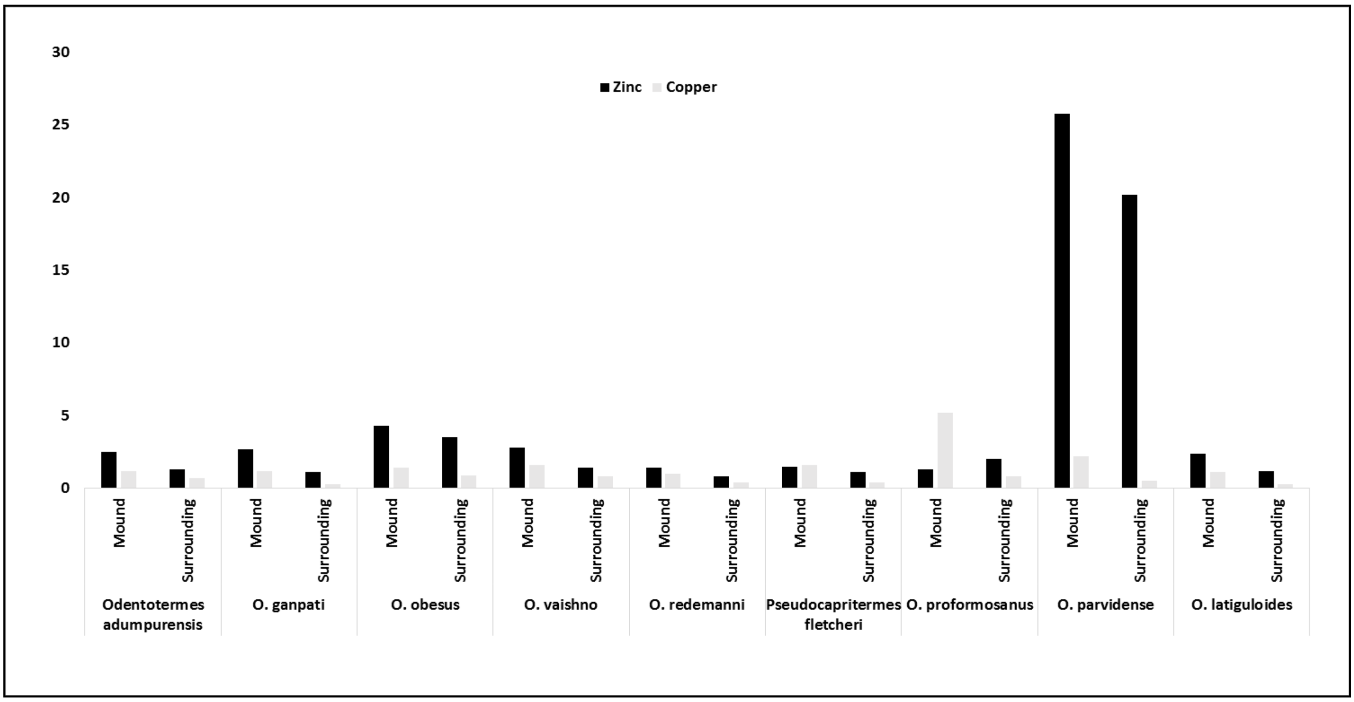
(Figure 1). Available 'Mn' was highest in *O. vaishno* (60.4 mg/ kg soil) and lowest in *O. obesus* (22.2 mg/kg soil) (Figure 1). Available 'Zn' was highest in *O. parvidense* (258 mg/kg soil) and lowest in *O. proformosanus* (1.3 mg/kg soil) (Figure 2). Available 'Cu' is highest in *O. proformosanus* (5.2 mg/ kg soil) and lowest in *O. redemanni* (1 mg/kg soil) (Figure 2). Higher available Fe, Zn and considerable amount of Mn and Cu contents recorded with *O. parvidense*.

Table 3: Soil micronutrient storage content (mg kg^{-1} soil) in mound structures and surrounding soils of different termite species. The values are mean±SE.

S. No	Termite species	Soil	Iron	Manganese	Zinc	Copper
1	*Odentotermes adumpurensis*	Mound	22.2 ± 1.50	52.4 ± 0.80	2.5 ± 0.20	1.2 ± 0.10
		Surrounding	13.5 ± 0.55	41.8 ± 0.37	1.3 ± 0.04	0.7 ± 0.04
2	*O. ganpati*	Mound	21.6 ± 1.50	41.5 ± 0.60	2.7 ± 0.40	1.2 ± 0.10
		Surrounding	11.5 ± 0.40	24.1 ± 0.70	1.1 ± 0.05	0.3 ± 0.02
3	*O. obesus*	Mound	20.5 ± 1.10	22.2 ± 0.90	4.3 ± 0.20	1.4 ± 0.10
		Surrounding	14.0 ± 0.50	12.1 ± 0.30	3.5 ± 0.03	0.9 ± 0.04
4	*O. vaishno*	Mound	23.3 ± 0.70	60.4 ± 2.30	2.8 ± 0.10	1.6 ± 0.06
		Surrounding	17.3 ± 0.40	51.5 ± 0.70	1.4 ± 0.05	0.8 ± 0.04
5	*O. redemanni*	Mound	34.8 ± 1.10	31.5 ± 0.70	1.4 ± 0.10	1.0 ± 0.10
		Surrounding	30.9 ± 0.40	23.1 ± 0.70	0.8 ± 0.04	0.4 ± 0.04
6	*Pseudocapritermes fletcheri*	Mound	27.2 ± 0.80	48.8 ± 0.70	1.5 ± 0.04	1.6 ± 0.03
		Surrounding	18.4 ± 0.40	34.2 ± 7.50	1.1 ± 0.04	0.4 ± 0.03
7	*O. proformosanus*	Mound	14.8 ± 0.43	49.8 ± 0.50	1.3 ± 0.09	5.2 ± 0.20
		Surrounding	7.5 ± 0.40	12.2 ± 0.60	2.0 ± 0.04	0.8 ± 0.20
8	*O. parvidense*	Mound	34.8 ± 0.80	55.7 ± 0.70	25.8± 1.20	2.2 ± 0.20
		Surrounding	90.5 ± 0.50	39.8 ± 0.70	20.2 ± 0.30	0.5 ± 0.06
9	*O. latiguloides*	Mound	17.4 ± 0.50	37.6 ± 1.60	2.4 ± 0.10	1.1 ± 0.10
		Surrounding	13.7 ± 0.4	24.9±1.2	1.2±0.1	0.3±0.04



Graph 1: Iron and Manganese status in termite mound and adjacent soils



Graph 2: Zinc and copper status in termite mound and adjacent soils

4. Discussion

Termites recreated soil that had properties beneficial than the adjacent soil in the study area. Termite mounds were enriched with micronutrients in relation to the control soil. Our pH results are in agreement with Brossard *et al.* [14] i.e. termite activity doesn't affect the soil pH in tasar ecosystem. Soil organic carbon is more in termite mound due to the fact that workers forage the organic matter and accumulate in the mound and degrade them Due to mineralization of soil organic matter in termite mounds leads to increased 'N' content [7]. Composition of soil alteration by termites is subject on termites' feeding behavior and materials employed during mound construction as such can have significant impact on phosphorus sorption affecting availability of phosphorus. Different termite species feeds on plant debris and constructs mound nests largely using soil material from deeper soil layers [15]. But *O. parvidense* mound soil had higher available 'P' as compared to other termite species. This might be due to that this termite constructed the mound from the adjacent soils or not so deep soils. The result is also confirmed with the study of Maduakor *et al.* [16]. Higher 'P' sorption and lower P availability in the mounds of selected termites than in the adjacent topsoils have been reported elsewhere [17]. Accumulated more free iron oxides in termite mounds than surrounding soils associated with clay enrichment by the action of termites which collects more clay from deeper layer to top for mound construction would increase soil 'P' fixation while lowering 'P' availability. Thus, lower available content of 'P' was observed with termite mound soil as compared to surrounding soils in the study. The similar finding is also corroborated by Abe and Wakatsuki [18].

Results reflect that the micro nutrients were more in termites and within termites, it is species specific (Figure 1, 2). *Odentotermes* sp built-up micronutrients in the mound construction to a greater degree, as indicated by their enhancement coefficients being higher than those of the available 'P' observed in this study. This implied that major parts of micronutrients built-up in the mound structures instigated from plant debris decomposition and the deposit of termite feces and dead termite bodies in addition to the assimilation of termite saliva during the mound building. Our study undoubtedly indicated enrichment of micronutrients in the mound structures, as compared to the adjacent control soils. It therefore, seems possible for tasar sericulture practicing farmers to use the termite mound debris, as a soil amendment, as proposed by Dangerfield *et al.* [8] and Duponnois *et al.* [19]. In particular, the use of termite debris would have a favorable effect on tasar host plants growth which are deficient in micronutrient. Also, termite can improve the soil nutrient-holding capacity as well as water retention capacity.

5. Conclusion

This study could be concluded that termite mound debris may be used as soil amendment owing to its higher nutrient content than the adjacent soils but it should be supplemented with phosphorus fertilizer where 'P' is deficient. However, valid recommendations should be necessitated for further research work on large scale in different tasar growing states with varied soil and environments prevails. Since tasar sericultural farmers being marginal, they cannot afford for costly chemical fertilizers. In order to produce the organic tasar silk, farmers should rely only on organic sources such as termite soil, a good alternative to chemical fertilizer and can be incorporated as a component into the integrated nutrient management for tasar silk production in sustainable approach.

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