Effect of earthworms on nutrients dynamics in soil and growth of crop

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Abstract
Effects of earthworms especially with Lumbricus terrestris on nutrients dynamics and on plant growth were studied in the laboratory. Soil was amended with varied levels of compost and earthworms were introduced: 60.9 g soil alone, 60.9 g soil + 20.78 g compost (60:40), 60.9 g soil + 41.57 g compost alone (80:20) and 41.57 g compost alone. The ion chromatography data showed there was significant variation in the nutrient status mainly nitrite, nitrate, ammonium and phosphate between the treatments (with worms) and control (devoid of worms). The significant variation in nitrite concentration was observed in treatment containing 60.9 g soil+ 20.78 g compost which was around 6.32 (mg/kg). Phosphate concentration was predominant in treatment having 41.57 g compost alone with 23.855 mg/kg concentration. The amount of ammonium varied slightly, though major concentration around 6.90 mg/kg was observed in treatment with 41.57 g compost alone. The difference in nutrient status appeared to be due to the variations in nutrient cycling probably ascribable to the earthworm's activities.

Pot experiment showed that the mustard plant growth was stimulated by earthworms digging capacity. The germination percentage, shoot length, root length and fresh biomass were determined. The variation between treatments and controls were measured. The average germination percentage in treatment containing 60.9 g soil + 20.78 g compost was 75.83 which was more significant, also accounts 8.51 cm and 3.5 cm shoot length and root length respectively. The total fresh biomass was measured to be 1.96 g more suggestive compared to controls. These modifications emerged due to the active participation of earthworms in stirring of soil.

Keywords
Bioremediation; soil; earthworm; nutrient; plant growth.

Introduction

Earthworms activities are deciding factors of soil fertility, its effect can be measured by various factors accordingly with time and space (climate, edaphic characters, and organic inputs). Earthworms exhibit Dilosphere concept to take part in soil function, which is a combination of earthworms, physical structures, whole microbial and invertebrate community. Earthworms induce microbial activities which inturn promotes organic matter processing and nutrient cycling.

Earthworm modify atmosphere apart from nutrient availability. Root feeding and dispersion of seed are some of the direct effects on plant growth by earthworms. Some of the indirect effects are alteration in soil properties, circulation of microbes and dissemination of microbes antipathetic to the root pathogens. Earthworms also help in breakdown of seed dormancy by gut passage and control the dispersion of organic matter which affects root foraging. It's also proved that effect of earthworm increases the nutrient composition in plant tissues (Stefan Scheu 2002). In the current study we investigated the role of earthworm in promoting nutrient status and plant growth.

Methods

Measurement of nutrients
Soil extraction with water is theoretically appropriate for nitrate that is very soluble, but for the inorganic forms of N not applicable. Therefore 0.5 mol/L potassium sulphate solution which enables solubility of calcium sulphate or potassium chloride for extraction of ammonium ions are recommended (Marc Pansu *et al*. 2006). Due to high sensitivity of IC apparatus extractions were carried out using Milli Q water.

Measurement of nutrients in soil
A 4 g soil was taken in centrifuge tubes from each treatments and 40 ml of Milli Q water was added. The tubes were placed in the mechanical shaker for overnight to ensure the solubility of ions. The tubes were placed in centrifuge and rotated for 15 min to get clear supernatant. The supernatant is collected and filtered using the millex filter and 10 ml from filtrate was taken to IC for measurement of nitrite (NO_2) and nitrate (NO_3).

Pot culture
Simultaneously mustard (white) seed were sown in the treatment beakers to examine the efficiency of plant growth with and without earthworms. Twenty seeds were placed in each beaker. To have clear idea of germination, the seeds were placed over the wet moisture filter paper over the soil surface and watered continuously for 15 days. The germination percentage; average shoot, root length and biomass were measured.

Results and Discussion
The initial characteristics of the soil and compost were calculated before the experiment started and given in Table 1. After 15 days the seeds in each treatment were germinated, the parameters like germination %, biomass, shoot and root length were calculated and presented in Table 2.

Table1. Initial characteristics of soil and compost:

Sl. No.	Characteristics	Soil	Compost
1.	pH	5.5	6

Only ph of the soil and compost was calculated.

Table2. Effect of earthworms and compost on growth of mustard

Sl. No.	Treatments	Without earthworms				With earthworms			
		Germination (%)	Biomass (g)	Shoot length (cm)	Root length (cm)	Germination (%)	Biomass (g)	Shoot length (cm)	Root length (cm)
1.	Soil alone	41.67	1.22	6.15	2.10	61.67	1.75	8.11	3.08
2.	Compost alone	54.17	1.66	7.25	2.51	60.83	1.91	7.98	2.92
3.	Soil + compost at 60:40 ratio	55.00	1.65	8.12	3.10	75.83	1.96	8.51	3.50
4.	Soil + compost at 80:20 ratio	58.33	1.92	7.61	2.72	65.00	1.92	8.32	3.30

Table3. Nutrients concentration in soil as affected by earthworms and compost

Sl. No.	Treatments	Without earthworms(mg/kg)				With earthworms(mg/kg)			
		Nitrite NO_2	Nitrate NO_3	Ammonium NH_4	Phosphate PO_4	NO_2	NO_3	NH_4	PO_4
1.	Soil alone	0.4999	17.51	0.416	1.0847	2.4218	19.543	5.27	3.623
2.	Compost alone	NA	NA	1.405	23.7133	0.9123	39.831	6.905	23.855
3.	Soil + compost at 60:40 ratio	0.4969	71.755	1.0991	9.723	6.327	4.734	4.668	12.116
4.	Soil + compost at 80:20 ratio	0.3235	102.492	1.506	11.85	0.816	28.012	0.728	7.843

The results from an Ion chromatography was calculated and given in Table 3. In total the ion chromatography calculated the value for many ions namely Fluoride, Chloride, Nitrite, Bromide, Nitrate, Sulphate, Oxalate, Phosphate, Sodium, Ammonium, Potassium, Magnesium and Calcium. Since the present experiment was concentrated on nitrite, nitrate, ammonium and phosphate only those values are recorded.

According to Lee 1985, the burrowing capacity of earthworms can be modified by the number of earthworms and other agricultural practices undertaken in the land area managed to reach more than 100 square metres. The digging capacity of earthworms play vital role in nutrient cycling and enriching the soil. In the present study the varied result may be due to the minor population of earthworm in each treatment. Due to the space constraint only two earthworms were accommodated in each treatment. Even though *L.terrestrics* is surface feeders which prefer organic matter to a greater extent and influence the nutrient status. Experiment conducted by Barley and Jennings (1959) with *A.caliginosa* species resulted in 129 ppm of nitrate and ammonium in 50 days where as treatments without earthworms resulted only 105 ppm (Edwards *et al*. 1977). The present study resulted in related solution with increased in quantity of ammonium, but the concentration of nitrite was not increased in treatments. This may be due to time constraint since the experiment was ran only about one month where as the previous experiment was extended upto 50 days. But remarkable variation was absorbed in nitrate concentration, which was increased in all treatments.

Conclusion

Earthworms are now greatly relied for increase in crop yield in the intensive agriculture system. Commercial production of earthworms started to gain popularity nowadays due to various studies which proved the efficiency of earthworms. From the current experiment, it is concluded that earthworm plays vital role in altering the nutrient composition in soil and promote plant growth. The earthworm activities clearly accelerate the nutrient release and sequential uptake of nutrients.

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References

Lavelle P (1988) Earthworm activities and the soil system. *Biol Fertil Soils* **6**, 237-251.
Syres JK, Springett JA (1984) Earthworms and soil fertility. Department of Soil Science, Massey University, and Ministry of Agriculture and Fisheries, Palmerston North, New Zealand, *Plant and Soil* **76**, 93-104.
Stefan Scheu (2002) Effects of earthworms on plant growth: patterns and perspectives. The 7th International Symposium on Earthworm Ecology, Cardiff, Wales, Submitted September 6.
Marc Pansu, Jacques Gautheyrou (2006) Handbook of soil analysis, mineralogical, organic and inorganic methods. Springer-Verlag Berlin Heidelberg, pp 597-598
Edwards CA, Lofty JR (1977) Biology of Earthworms. Chapman and Hall. A Halsted Press Book.
Lunt HA, Jacobson GM (1944) The chemical composition of earthworm casts. *Soil science* **58**, 367-376
Laverack MS (1963) The physiology of earthworms, Pergamon press
Spider GA, Gagnon D, Nason GE, Packee EC, Lousier JD (1986) Effects and importance of indigenous earthworms on decomposition and nutrient cycling in coastal forest ecosystem, pp.983-989.
Haimi J, Einbork ME (1991) Effects of endogeic earthworms on soil processes and plant growth in coniferous forest soil. *Biol Fertil Soils* **13**, 6-10.
Edwards CA, Lofty JR (1976) Effects of earthworm inoculation upon the root growth of direct drilled cereals. *Journal of applied ecology* **17**, 533-543.
Atlavinyte O, Bagdonaviciene Z, Budaviciene (1968) The effect of Lumbricidae on the barley crops in various soils. *Pedobiologia* **8**, 415-423.
Graft O, Makeschin F (1971) Crop yield of ryegrass influenced by the excretions of three earthworm species. *Pedobiologia* **20**, 176-180.
Barley KP, Jenings JP (1959) Earthworms and soil fertility: The influence of earthworms on the available nitrogen. *Australian journal of Agricultural research* **10**(3), 364- 370.
Bhadauria T, Ramakrishnan PS (1991) Population dynamics of earthworms and their activities in forest ecosystems of north east India. *Journal of Tropical Ecology* **7**, 305-318,