

## Effects of organic manure and NPK fertilization on earthworm activity in an Oxisol

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**Abstract.** The effects of fertilization with N, P, K, and organic manure (alone or in combination) on earthworm populations, biomass, and casting activity were measured in a cultivated soil (organic C 1.5%, annual rainfall 2000–2300 mm). These applications of fertilizer caused significant increases in earthworm numbers, biomass, and casts. N alone or in combination with P and K also influenced these earthworm parameters significantly. The inorganic NPK fertilizer in combination with organic manure had a significantly greater effect on earthworm activities than NPK fertilizer alone, and therefore the addition of organic matter appears advisable in order to obtain maximum benefits from NPK fertilizer in this soil.

**Key words:** Casting activity – Earthworm number – Mineral fertilizer – Organic manure – pH – Earthworm biomass – *Drawida assamensis*

The importance of earthworm in the breakdown and incorporation of organic matter into the soil is well established (Edwards and Lofty 1977; Edwards 1981). Earthworm populations are influenced by various factors (soil temperature, moisture, pH) and the availability of organic matter for food, which may come from plant residues and animal or human waste applied to the land. Traditionally, large quantities of farmyard manure were used in agriculture but as the housing of pigs and cattle has intensified globally, the widespread use of farmyard manure has been superseded by inorganic fertilizers.

Considering the extensive use of organic manures and NPK fertilizers, little is known about their effects on earthworm activities in the soil. The effects of organic and inorganic manure on earthworm populations and activities in arable crops have been studied extensively (Lee 1985). Only one of these studies concerns the effects of

organic manure and NPK fertilizer on earthworm activities in subtropical soils. The aim of the present experiment was to study the short-term effects of organic manure and NPK fertilizer on earthworm activities.

### Materials and methods

The study was conducted at the Pineapple Research Station, Nayabunglow (altitude 800 m; 25° 44' N, 91° 53' E), Shillong, India. The study soil (a sandy loam) was classified as an Oxisol with pH of 5.8 (Table 1). The organic manure used had a somewhat higher content of organic C and N than the soil. The available P and exchangeable K contents of the soil were low (Table 1).

Seven areas (blocks) of approximately equal size were selected for the study. The native vegetation and the top 2–3 cm of soil were mechanically stripped from the blocks. The soil was then ploughed to a depth of 30 cm. Each of the seven blocks was divided into 5 m<sup>2</sup> subplots. Seven treatments were applied, control (no fertilizer), N, P, K, organic manure, NPK in combination, and NPK in combination with organic manure. They were laid out in a complete block design with seven replications. N was applied as urea at 30 kg N ha<sup>-1</sup>, P as single superphosphate at 25 kg P ha<sup>-1</sup>, and K as potash (KCl) at 15 kg K ha<sup>-1</sup>. The dose of NPK was based on the dose generally used in North Eastern India.

Partly decomposed cow dung was used as organic manure. It was added to the subplots at the rate of 10 × 10<sup>3</sup> kg ha<sup>-1</sup> (dry weight basis) and mixed with the topsoil, using a fork. The organic manure was sampled for dry matter, C, and N before it was applied to the soil. Thirty days later the NPK fertilizer was hand-broadcast onto the appropriate plots and mixed thoroughly with the topsoil, using a fork. All plots were weeded weekly. The control plots were treated in the same way, except that they were not fertilized.

Soil samples were collected from all treated and control plots 60 days after the organic manure application and 30 days after NPK application. The samples were collected from three random locations in each subplot by digging the soil to a depth of 30 cm with a fork. Composite samples from similar plots were used for the determination of soil physicochemical characteristics.

Earthworm activities were measured in terms of population, biomass, and cast production in each treated and control plot. Earthworms were extracted by hand-sorting (Edwards and Lofty 1977) from a 1-m<sup>2</sup> quadrat in each replicate plot. The soil (30 cm depth) from the 1 × 1 m quadrat was dug up and earthworms were picked out by hand and allowed to evacuate their guts naturally on paper before drying and weighing (Yeates 1976). The earthworm species found in this study were active to a soil depth of 30 cm. The earthworm biomass (expressed in

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terms of dry body weight) was determined by drying a subsample in a hot-air oven at 80°C for 24 h (Martin 1986). The number of earthworm casts was recorded and the surface casts were carefully scooped into paper envelopes for drying and weighing. The casts were oven-dried at 105°C for 24 h.

Samples were analysed for the determination of pH, organic C, total N, available P, and exchangeable K, using methods described by Allen (1974). For the N, P, K and organic C measurements the samples were air-dried and passed through a <0.2-mm sieve. Walkley and Black's rapid titration method, using diphenylamine as an indicator, was used for the determination of organic C. Total N was estimated by a semimicro-Kjeldahl method. Exchangeable K was extracted in ammonium acetate solution (575 ml acetic acid + 600 ml ammonia solution, pH 7) and measured by flame photometer (Systronics-121). A molybdenum blue method, using Bray's extraction solution (1.11 g ammonium fluoride dissolved in 1 litre HCl), was used to measure available P. Extinction of the blue colour was read spectrophotometrically (Hitachi-220) at 660 nm.

In order to study the effects of organic manure and NPK fertilizer on earthworm populations, biomass, and casting activity, the data recorded for each parameter were pooled together among replicates (seven) and analysed statistically using least significant differences (LSD) at  $P = 0.05, 0.01, \text{ and } 0.001$ .

## Results

Five species of earthworms were found in the present study, *Amyntas alexandri*, *Drawida assamensis*, *Megascolides antrophyes*, *Metaphire houlleti*, and *Neloscocles strigosus*. *Drawida assamensis* was the dominant species. The earthworm population was significantly ( $P = 0.05$ ) greater in plots treated with organic manure or with NPK or a combination of both than in the control plots (Table 2). The N, P, and K treatments had no significant

effect on the earthworm population. The differences in earthworm biomass in the various treatments were closely related to the differences in population (Table 2). The number of casts was higher with N, K, organic matter, and the combination of NPK and organic matter but less with P, NPK, and in the control plots (Table 2). N, K, organic matter, and the NPK-organic matter treatments influenced cast production significantly ( $P = 0.01$ ), but the other treatments did not. The dry weight of worm casts (Table 2) followed a similar trend to the number of worm casts.

## Discussion

The NPK-organic matter plots received both inorganic and organic N and had the highest population of earthworms. Similarly, Edwards and Lofty (1982) found increases in earthworm populations in arable soils that were fertilized with both inorganic and organic N. In contrast, Ma et al. (1990) recorded a drastic decrease in earthworm populations and biomass in grassland soils treated only with nitrogenous fertilizers. The organic fertilizers probably provide food directly for the earthworms and this might be the reason for the higher earthworm populations in the plots treated with organic matter or NPK+organic matter in the present study. Presumably, the influence of organic manure on earthworm species is mainly through an increase in their food supply, whether they feed directly on the organic matter or on microorganisms growing upon it. Edwards and Lofty (1982) re-

**Table 1.** Chemical analysis of soil and organic manure

	Organic C (%)	Total N (%)	Available P (%)	Exchangeable K (%)	C:N ratio	pH
Soil	1.5	0.48	0.01	0.008	3.13	5.8
Organic manure	12.5	1.67	ND	ND	7.5	ND
	Sand (%)	Silt (%)	Clay (%)	Texture	Classification	
	58.0	26.0	16.0	Sandy loam	Oxisol	

Data presented are on a dry weight (105°C) basis. ND, Not determined

**Table 2.** Effects of organic manure and NPK fertilization on earthworm population, biomass, and casting activity in soil

Treatment	Population (no. m <sup>2</sup> )	Biomass (dry weight g m <sup>-2</sup> )	Casts (no. m <sup>2</sup> )	Casts (dry weight g m <sup>-2</sup> )	pH
Control (no fertilizer)	12	8.3	12	16.3	5.8
Urea (30 kg ha <sup>-1</sup> )	24	14.3	21	39.3	5.7
SSP (25 kg ha <sup>-1</sup> )	16	11.5	18	21.2	5.6
KCl (15 kg ha <sup>-1</sup> )	15	10.3	24	51.6	5.4
Organic manure (10 × 10 <sup>3</sup> kg ha <sup>-1</sup> )	60	40.3	36	96.3	6.1
Urea + SSP + KCl	42	28.4	8	24.5	5.3
Urea + SSP + KCl + organic manure	85	61.4	58	152.6	5.9
LSD	11.3	14.3	8.3	16.5	NS
	$P = 0.05$	$P = 0.01$	$P = 0.01$	$P = 0.01$	

SSP, P as single superphosphate; LSD, least significant difference

ported that organic N had a greater effect on earthworm populations than inorganic N. They also found little increase in earthworm numbers with P and K fertilization.

The largest earthworm biomass was recorded from the NPK–organic matter-treated plots and this may be attributed to the presence of both inorganic and organic N in sufficient quantities, as most earthworm species prefer food that has a high N content (Satchell 1967). Lal and De Vleeschauwer (1982) measured earthworm activity by the casting frequency and recorded higher levels of casting activity on richer soil than on poorer soil. The higher levels of casting activity in the plots treated with organic matter or with organic matter+NPK in the present study may have been due to the richness of these plots in those nutrients. The N, organic matter, and NPK–organic matter treatments stimulated earthworm activity to varying extents, showing that NPK fertilizer in combination with organic manure is important. The general lack of any effect of N, P, and K without organic matter on earthworm casting may have been related to the acidifying effect of these treatments on soil (Lee 1985). The effects of organic manure, and N, P, and K fertilizer, alone or in combination, on earthworm activity were generally in accord with the effects of these treatments on soil pH (Table 2).

The results of the present investigation clearly demonstrate that treatment with inorganic fertilizer (N, P, and K) in combination with organic manure had significantly greater effects on earthworm activity than the control and other treated plots. Though other available evidence is slender, it seems likely, therefore, that inorganic fertilizers applied in combination with organic manure to cultivated land increase earthworm populations, biomass, and production of casts much more than inorganic fertilizers

alone. Therefore, the use of NPK fertilizer in addition to organic manure appears advisable to derive more benefits from nitrogenous, potash, and phosphatic fertilizers in acidic soils of subtropical regions.

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