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INFLUENCE OF EARTHWORM ACTIVITY ON SOIL FERTILITY IN AGROFORESTRY SYSTEMS

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ABSTRACT

Investigations were carried out to study the effect of earthworm activity on fertility status of rainfed red sandy loam soil under *Acacia tortilis* and *Leucaena leucocephala* in association with *Stylosanthes hamata* and *Cenchrus ciliaris*. Earthworm casts were more abundant and of larger size around *A. tortilis* than around *L. leucocephala*. The pH and EC values increased due to earthworm activity whereas silt and clay contents decreased in the casts. Worm-casts contained 1.2 to 1.7 times more available P_2O_5 and 1.4 to 1.6 times more available K_2O as compared to the parent soil collected from 15 cm depth. As a result of earthworm activity, 12 g of organic carbon, 39 mg of nitrogen, 19 mg of P_2O_5 and 192 mg of K_2O were added per square metre area around *A tortilis* by 64 worm-casts whereas 1.43 g organic carbon, 5.4 mg nitrogen, 3.5 mg P_2O_5 and 17 mg K_2O were increased per square metre around *L. leucocephala* + *S. hamata* by 54 worm-casts and 0.87 g organic carbon, 4.9 mg nitrogen, 2.6 mg P_2O_5 and 15 mg K_2O were increased per square metre around *L. leucocephala* + *C. ciliaris* by 44 worm-casts.

INTRODUCTION

Abundant activity of earthworms is an important factor in fertility modification in the soil by the process of eluviation involving downward movement of clay and other suspended colloids (Lal, 1979). The chemical properties of the soil are also affected as a result of earthworm activity (Barley, 1961; and Barley and Kleinig, 1964). In the tropics, however, the relevance of earthworms to soil physical and nutritional characteristics has not been widely researched. Earthworms may produce worm-casts at the rate of about 50t ha^{-1} $year^{-1}$ under favourable conditions (Lal, 1979). They incorporate and help to decompose organic matter into the soil and their tunnel making helps in soil aeration. Worm-casts are also stable to the impact of rain drops and, therefore, may reduce soil splash (Lal and Vleeschauwer, 1982). An attempt has been made in this paper to study the effect of earthworm activity on nutrient status of soil under *Acacia tortilis* (Forsk.) Hayne and *Leucaena leucocephala* (Lam.) de Wit in association with *Stylosanthes hamata* (L.) Taub and *Cenchrus ciliaris* L.

MATERIAL AND METHODS

Analyses were conducted on soil samples and worm-casts collected from an on-going long term experiment on agroforestry initiated in 1981 with *A. tortilis* and *L. leucocephala* in association with *S. hamata* and *C. ciliaris* at Hayatangar Resea[rch] Farm, Hyderabad. In August 1986, worm-casts from the surface of red san[dy loam] soil in one metre area around a tree and in between two trees at nine plo[ts] collected by hand sorting with three replications in each system. Correspondin[g] samples from 15 cm x 15 cm area were also collected. The samples were air dri[ed] ground gently and sieved through a 2-mm sieve.

The pH was determined by water suspension at a 1: 2.5 ratio, EC by filtration of above suspension and then reading in conductivity bridge (Systronics Digital), mechanical anaysis was done by Bouyoucous hydrometer, organic carbon by dichromate oxidation, available N by Kjeldahl method with Kjeltec Auto 1030 analyser, available P_2O_5 by alkaline sodium bicarbonate extraction and available K_2O by ammonium acetate extraction and flame photometer.

RESULTS AND DISCUSSION

Earthworm casts were more abundant (64 per sq m) and heavier around *A. tortilis* than around *L. leucocephala* + *S. hamata* (54 per sq m) and *L. leucocephala* + *C. ciliaris* (44 per sq m) as is evident from the data set out in Table 1.

Table 1. Abundance of earthworm and amount of nutrients in worm-casts per square metre soil around the trees in agroforestry systems

System	Total worm-casts		Organic	Total available nutrients (mg)		
	No.	Wt (g)	carbon (g)	N	P_2O_5	K_2O
A tortilis	58-101 (64.3)	547-988 (733-55)	12.03	39	19	192
L. lecocephala + *S. hamata*	43-67 (54.0)	85-147 (116.00)	1.43	5.4	3.5	17
L. leucocephala + *C. ciliaris*	37-56 (44.1)	70-121 (108.88)	0.87	4.9	2.6	15

Both the worm-casts and soil samples were sandy loam in texture (Table 2). However, the silt and clay contents were less in the worm-casts as compared to parent soil. The soil pH and electrical conductivity were also affected by eartnworm activity. The mean pH of worm-casts was higher than the soil by 0.5 to 0.9 units (Table 2). These results are in agreement with earlier reports of Barley (1961) and Edward et al. (1970) but contradict the observations of Lal and Vleeschauwer (1982) who reported that pH of worm-casts was lower than the parent soil by 0.2-0.3 units. Barley (1961) reported that, as a result of earthworms feeding on a mixture of organic material and

soil, the pH of soil tended to approach neutrality, on matter whether the soil was initially acidic or alkaline. Electrical conductivity also followed the same trend as pH (Table 2).

Table 2. Textural composition of soil and worm-casts

System	pH		EC		Coarse sand		Fine sand		Silt		Clay	
	Worm-cast	Soil	Worm-cast	Soil	Worm-cast	Soil	Worm-cast	Soil	Worm-cast	Soil	Worm-cast	Soil
A tortilis	6.99	6.49	0 1	<0.1	81.34	80.24	5.0	2.0	2.30	3.70	11.36	14.06
L. leucocephala + *S. hamata*	7.04	6.11	0.1	<0.1	83.64	82.34	2.0	1.0	2.00	2.70	12.36	13.96
L. leucocephala + *C. ciliaris*	6.76	6.27	0.1	<0.1	83.94	80.04	4.0	3.0	2.00	2.60	10.06	14.36

Organic Carbon and Nitrogen

The organic carbon and available nitrogen contents were significantly enhanced by earthworm activity. The organic carbon increased 1.7 fold in casts around *A. tortilis*- 1.5 fold in worm-casts around *L. leucocephala* + *S. hamata* and 1.2 fold in worm, casts around *L. leucocephala* + *C. ciliaris* compared to the parent soil. Available N followed a trend similar to organic carbon. There was about 2.0 times more available N in worm casts around *A. tortilis* 1.8 times more around *L. leucocephala* + *S. hamata* and 1.4 times more around *L leucocephala* + *C. ciliaris* (Table 3) than the parent soil in situ. Higher values of organic carbon and available N in the worm casts may be due to repid mineralization of crop residue because earthworms have a positive effect on N-fixing bacteria (Day, 1950, Khambatta and Bhatt, 1957). The increase in available N may also be due to decay of dead worms (Satchell, 1958). When calculated on the basis of weight of worm-casts, 12 g of organic carbon and 39 mg of nitrogen were added per square metre area around *A. tortilis*, whereas 1.43 g of organic carbon and 5.4 mg nitrogen were added per square metre area around *L. leucocephala* + *S. hamata* and 0.87 g of organic carbon and 4 9 mg of N were added per square metre area around *L. leucocephala* + *C. ciliaris* (Table 1).

Table 3. Nutrient status of soil and worm-casts under different agroforestry system

	Organic carbon (%)		Available N (ppm)		Available P_2O_5 (ppm)		Available K_2O(ppm)	
	Worm-casts	Soil	Worm-casts	Soil	Worm-casts	Soil	Worm-casts	Soil
A. tortilis	1.64	0.95	53.33	27.23	25.01	8.03	261.50	166.01
L. leucocephala + *S. hamata*	1.24	0.83	46.28	26.04	30.08	10.53	143.59	101.37
L leucocephala + *C. ciliaris*	0.80	0.67	45.40	32.08	24.20	8.79	136.30	97.63
S Em ±	0.609		1.054		0.8531		7.1338	
CD (5%)	0.174		3.0075		ns		ns	

Available P_2O_5 and K_2O

There was significant increase in available P_2O_5 and K_2O as a result of earthworm activity. Available P_2O_5 was 3.2 times higher in worm-casts around *A. tortilis* and 2.8 and 2.7 times higher in *L. leucocephala* + *S. hamata* and *L. leucocephala* + *C. ciliaris*, respectively (Table 3). Similarly, there were significant differences in the available K_2O values of worm-casts and soil samples. The casts around *A. tortilis* had 1.6 times more K_3O both in *S. hamata* and *C. ciliaris* systems (Table 3). In one metre area around the trees where the casts were collected, 19 mg of P_2O_5 and 192 mg K_2O were added as a result of earthworm activity around *A. tortilis* whereas around *L. leucocephala* + *S. hamata*, 3.5 mg P_2O_5 and 17 mg K_2O and around *L. leucocephala* + *C. ciliaris*, 2.6 mg P_2O_5 and 15 mg K_2O were added (Table 1).

The above data show that effect of earthworm activity on available P_2O_5 and K_2O was significant. The higher concentrations of available P_2O_5 and K_2O in the worm-casts could be due to rapid mineralization and carriage of nutrients from subsoil horizon to surface and rendering them into readily available form. Barley (1961) reported that calcium ions in solution in the gut of earthworm were absorbed and the surplus excreted into the gut as calcium carbonate. This process, togetherwith break down of organic matter within the gut, affects the pH of the excreted soil and hence the solubility of various nutrients in the worm-casts. Therefore, it can be concluded that earthworms are beneficial to the soil as they improve the soil texture, increase the pH/EC and enhance the concentration of nutrients in the available form and decrease the nutrient losses due to leaching by temporarily immobilising them in their biomass and excrement (Lal and Vleeschauwer, 1982). Earthworms thus play a highly positive role in fertility build-up which is very much desirable in semi-arid situations.

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