The application of filter cakes improves the physicochemical and biological properties of soils with low pH in tropical regions

The application of organic matter is recommended for carbon sequestration and fertility improvement in agricultural soils. Sugarcane is widely cultivated in tropical regions, and a large amount of filter cake (FC) is produced as a by-product in the sugar industry. Earthworms (Oligochaeta) can improve soil functions such as nutrient cycling and water retention by promoting organic matter decomposition and modifying soil structure through their feeding and casting activities. Organic matter application is known to increase earthworm density and biomass. Also, soil pH can influence earthworm species composition, density, and biomass. However, the effects of organic amendments on these characteristics of earthworms at different soil pH values have not been fully understood, especially in tropical agricultural fields.

We conducted a field survey to evaluate the effects of a single application of FC on soil physicochemical properties and earthworm species, density, and biomass in sugarcane fields with two different soil pHs (low pH soil : <5.2, moderate pH soil : >6.0) on Ishigaki Island, Okinawa Prefecture, Japan. FC application decreased soil bulk density and hardness, and water content increased in the low pH soil. In addition, available P content and Ca^{2+}, K^{+}, and Mg^{2+} contents increased about 2-fold, and cation exchange capacity also increased (Table 1). In the moderate pH soil, FC application did not improve physical properties, although the available P increased 2.5-fold, and soil pH and Ca^{2+} and K^{+} contents decreased. Regardless of soil pH and FC application, *Pontoscolex corethrurus* (Müller, 1856) was dominant (Fig. 1) and accounted for approximately 30% to 100% of the density in each treatment. In addition to *P. corethrurus*, *Polypheretima elongata* (Perrier, 1872) was observed in the low pH soil with FC application. Earthworm biomass increased about 3-fold in the low pH soil but decreased by about 80% in the moderate pH soil with FC application (Fig. 2). Therefore, FC application to low pH soils can improve both physicochemical and biological properties of the soil.

Our results suggest that the application of FC, an underutilized organic resource, is expected to improve soil functions such as nutrient cycling and water retention in low pH soils through enhanced biological properties. Since this conclusion is based on data from a single application of FC, the effects of continuous application of FC and the effects of application of organic materials with different chemical properties from FC on soil physical and chemical properties need to be investigated. Additionally, future evaluations should include yield assessments.

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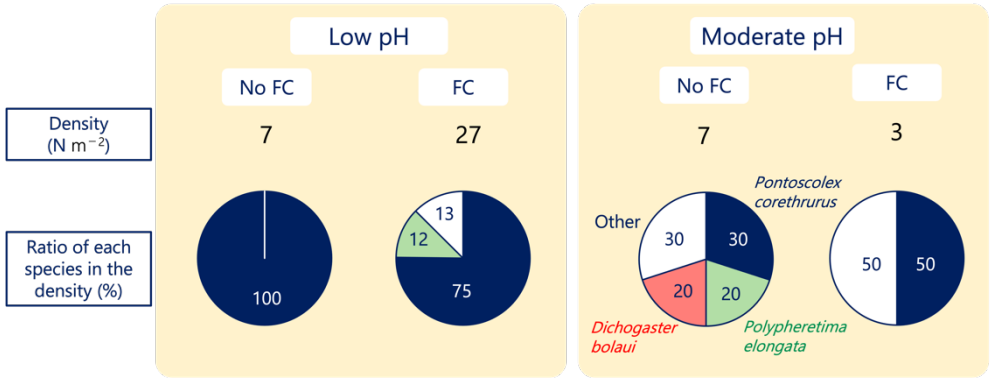
Table 1. Effect of filter cake application on physicochemical properties of soils at low pH and moderate pH

Soil pH	FC	pH (H_2O)	EC	Bulk density	Water content	Hardness	TC	C:N ratio	Available P	Ca^{2+}	K^+	Mg^{2+}	CEC
			mS m^{-1}	Mg m^{-3}	m^3 m^{-3}	mm	g kg^{-1}		µg kg^{-1}	cmolc kg^{-1}	cmolc kg^{-1}	cmolc kg^{-1}	cmol(+) kg^{-1}
Low	No	4.74 (0.21)	6.35 (0.90)	1.22 (0.11)	0.21 (0.01)	12.32 (1.75)	9.69 (2.07)	9.89 (0.63)	115.6 (31.1)	1.74 (0.92)	0.27 (0.02)	0.42 (0.15)	13.22 (0.46)
	Yes	4.98 (0.38)	9.40 (2.33)	1.15 (0.14)	0.25 (0.02)	8.63 (0.98)	9.48 (1.55)	9.46 (0.41)	209.7 (21.1)	3.80 (1.39)	0.53 (0.19)	0.78 (0.14)	13.71 (2.65)
	p value		***	**	**	*		*	***	***	***	***	***
Moderate	No	6.50 (0.27)	6.76 (1.12)	1.20 (0.02)	0.22 (0.04)	7.40 (1.51)	9.19 (2.33)	9.82 (0.42)	125.7 (19.9)	10.25 (2.55)	0.61 (0.19)	1.33 (0.34)	16.60 (4.06)
	Yes	5.54 (0.20)	7.98 (1.27)	1.25 (0.16)	0.24 (0.03)	9.99 (3.13)	11.33 (2.17)	9.88 (0.29)	316.2 (67.6)	5.29 (1.27)	0.46 (0.06)	1.10 (0.13)	15.71 (2.93)
	p value		***						***	**	***		

Three pairs of adjacent sugarcane fields with and without filter cake application were selected in each of the low (< 5.2) and moderate (> 6.0) pH soils. FC: filter cake; EC: electrical conductivity; TC: total carbon content; C:N ratio: ratio of total carbon to total nitrogen. All cations are exchangeable. *p < 0.05; **p < 0.01; ***p < 0.001. Values represent the mean (standard error) of three experimental plots.

Fig. 1. Density of earthworms and proportion of each species in the density

The numbers at the top of the pie chart indicate the density (N m^{-2}), and the numbers within the pie chart indicate the proportion of each species in the density (%). Blue: *Pontoscolex corethrurus* (Müller, 1856), Green: *Polypheretima elongata* (Perrier, 1872), Red: *Dichogaster bolaui* (Michaelsen, 1891), White/Other: represents individuals for which species identification was not possible due to fragments. Earthworms were collected by hand sorting soil at 0–10 cm depth corresponding to Table 1 and by mustard solution at a depth deeper than 10 cm.



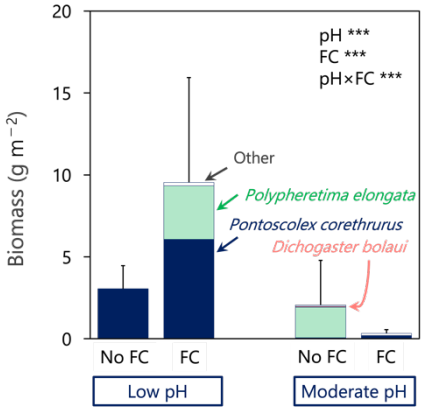


Fig. 2. Effect of filter cake application on earthworm biomass in each pH soil

Earthworm biomass for each species (g m^{-2}), corresponding to Figure 1 data. Error bars represent standard errors of total earthworm biomass in the three sugarcane fields. ***p < 0.05.

Reference: Arai et al. (2024) *European Journal of Soil Biology* 122: 103645.