Soil Use and Management (2005) **21**, 260–261 DOI: 10.1079/SUM2005309

Changes in an Alfisol under long-term application of manure and inorganic fertilizer

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Abstract. Changes in surface soil properties of a savanna Alfisol under cultivation with applications of manure and inorganic NPK fertilizer were evaluated after 45 years of annual cropping. Soils from treatments with fertilizer only, fertilizer in combination with farmyard manure (FYM) at both high and low rates were compared to soil from a control receiving neither fertilizer nor manure. The high rate of FYM and fertilizer significantly improved soil aggregation, increased C, N and P status, while reducing soil penetration resistance. The results showed that there is a need to use both manure and inorganic fertilizer to maintain soil fertility in savanna soils under continuous cultivation.

Keywords: Alfisol, manure, fertilizer, sustainable fertility

INTRODUCTION

Most African savanna soils contain low activity clay and their fertility declines under continuous arable cropping. Loss of soil organic matter and nutrient deficient topsoil coupled with high bulk density and weak aggregation are common features that pose a major threat to soil productivity and sustainable agriculture in the dry savanna. In this communication the effects on an Alfisol of 45 years of cropping with application of farmyard manure (FYM) and inorganic NPK fertilizer are compared to using NPK fertilizer only.

METHODS

From the long-term FYM and NPK trial at Samaru, 15 composite surface soil samples were taken randomly from five selected treatments: FYM (dung) and inorganic fertilizer (D + NPK) at two rates; NPK at two rates; and a control receiving neither FYM nor fertilizer. Details of the long-term trial have been reported by Ogunwole & Ogunleye (2004).

Soil organic carbon (SOC) and total N were determined by wet combustion and Kjeldahl distillation methods respectively (Page *et al.* 1982). Available P was determined by the acid–fluoride extraction method of Bray & Kurtz (1945). Aggregate size was determined by dry sieving soil through a nest of sieves for 3 min. As an index of stability, mean weight diameter (MWD) was calculated as the cumulative sum of each fraction multiplied by the corresponding mean mesh size of the two sieves passing and retaining the fraction. Penetration resistance of the soil surface (0–7.5 cm) was measured with a Farnell soil penetrometer. All data were analysed using ANOVA and the GLM procedure of SAS (1987).

RESULTS AND DISCUSSION

The lowest soil fertility was recorded in the low rate NPK treatment without FYM. Soil in this treatment contained less SOC and had a higher penetration resistance even than the control (Table 1). The most fertile soil was from the double rate FYM + NPK treatment which contained nearly twice the SOC and total N of the other treatments and much lower penetration resistance. Soil from the double rate NPK treatment was nearly as fertile as that from the lower rate FYM + NPK treatment except that the FYM significantly reduced the penetration resistance. The MWD of aggregates was similar in all treatments except for a significantly smaller value in soil from the single rate NPK. The larger the MWD, the less the tendency for rain storms to cause surface slaking and cap formation.

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Table 1. Changes of an Alfisol under long-term application of manure and inorganic fertilizer.

Amendments[a]	Mean weight diameter (mm)	SOC	Total N	Available P ($mg\,kg^{-1}$)	Soil penetrometer resistance (kPa)	Aggregate distribution (mm)			
		($g\,kg^{-1}$)				1.60	0.9	0.43	0.13
Control	0.40b	6.39b	0.59b	5.28ab	510.7b	0.12b	0.16b	0.07c	0.010b
D + NPK (high rate)	0.45ab	11.37a	1.01a	14.86a	284.9c	0.17a	0.16b	0.08c	0.013b
D + NPK (low rate)	0.43ab	6.60b	0.70b	4.77ab	362.9c	0.08b	0.15b	0.09b	0.070a
NPK (high rate)	0.47a	7.73b	0.74b	5.50ab	484.9b	0.12b	0.20a	0.10a	0.010b
NPK (low rate)	0.38b	5.87	0.58b	2.57b	593.9a	0.1b	0.15b	0.08c	0.010b
SE	0.02	1.03	0.083	3.43	25.14	0.013	0.008	0.003	0.002

[a] Lower rate for dung (D) was $2.5\,t\,ha^{-1}$ and lower rates for NPK fertilizer were $24–67.5\,kg\,N\,ha^{-1}$, $9–27\,kg\,P\,ha^{-1}$ and $14.5–29\,kg\,K\,ha^{-1}$, while the higher rates for D and NPK were twice the respective lower rates. Values in the columns with the same small letters are not significantly different at $P = 0.05$. SE = standard error.

The data in Table 1 indicate that the long-term complementary use of FYM at $5\,t\,ha^{-1}$ or more and NPK fertilizer at an appropriate rate will improve the physical and chemical fertility of continuously cropped savanna Alfisol.

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Received July 2004, accepted after revisions December 2004.