Integrated nutrient management: Preliminary results from a 2-year field trial using cowdung, mineral fertilizer and maize test crop in the interior savanna zone of Ghana

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Abstract

On station trials were conducted in 2 years at Manga Research Station in the interior savanna zone of Ghana to evaluate integrated nutrient (cowdung and mineral fertilizer) management for sustainable maize production. The application of fertilizer alone at a rate of 60-40-40 kg $NP_2O_5K_2O$ ha^{-1} gave yields (stover and grain) of 90 per cent, over the control. The use of either 4 t ha^{-1} or 8 t ha^{-1} of cowdung only did not significantly increase the yields over the control. However, the combination of 60-40-40 $NP_2O_5K_2O$ ha^{-1} of inorganic fertilizer with 4 t ha^{-1} or 8 t ha^{-1} of cowdung significantly increased yields. Also, half rate of inorganic fertilizer 30-20-20 kg $NP_2O_5K_2O$ ha^{-1} plus either 2 t ha^{-1} or 4 t ha^{-1} of cowdung gave significant yields over the control. The results indicate that integrated nutrient management is needed for sustainable maize production in the zone.

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Introduction

Maize *(Zea mays)* is now an important crop in the farming system of the interior savanna zone of Ghana. However, low soil fertility is a major constraint to its sustainable production. Therefore, improvement of its production depends on ameliorating the inherent low soil fertility. Maintenance of soil fertility by the traditional practice of shifting cultivation is no longer practicable in the interior savanna zone of Ghana. Rising human population has put too much pressure on the land leading to continuous cropping. This has led to low soil fertility, negative nutrient budgets brought about by crop removal at harvest, and poor land husbandry practices.

The yields of the traditional crops (millet and sorghum) are too low to support the rising food demand of the human population. Maize production was, therefore, introduced to raise more cereals for the people. However, earlier attempts by the Ministry of Food and Agriculture, Global 2000 and other NGOs, who started the promotion of maize production, supported it with highly subsidized mineral fertilizers. These efforts significantly increased maize yield to over 1.2 t ha^{-1} as compared to 0.6 t ha^{-1} under farmers' practice by using 200 kg ha^{-1} of NPK fertilizers (UER-IFAD/LACOSREP, 1992).

With the complete removal of fertilizer subsidy, most farmers can no longer buy and apply fertilizers due to high prices, and, as a result, maize yields are rapidly decreasing. On the other hand, cowdung has traditionally been accepted as source of nutrients for crops in this ecological zone (Mensah Bonsu & Obeng, 1978; Anane-Sakyi *et al.*, 1997). There is, therefore, an urgent need to develope integrated nutrient management for sustainable maize production by using organic and mineral fertilizers.

Many workers have recorded the supply of nutrients especially nitrogen, phosphorus and micro nutrients (Musa, 1975; Olsen *et al.*, 1970) from cowdung to crops which tend to have immediate positive effect on their yields. Numerous experiments conducted in the semi-arid regions in West Africa showed increase in crop yields from the application of cowdung (Nye, 1952; Djokoto & Stephen, 1961; Poulain, 1976; Pieri, 1971; Kwakye,1980). Dennis *et al.*,1994 have indicated that the best fertilization for savanna soil is a combination of organic (cowdung) and mineral fertilizers, This does not only increase crop yields, but also improves the fertility status of the soil. This paper, therefore, highlights the results of 2 years integrated nutrient management trial for sustainable maize production at Manga Research Station.

Materials and methods

The experiment was conducted at Manga Research Station (11° 01' N, 00° 16' W, 249 m above sea level). The annual mean rainfall (1996-1997) of the experiment site was 934.2 mm; it is monomodal, starting in April and ending in October, with a short dry spell in July and the peak in August. The site was on a slope of about 2 per cent and the soil is Plinthic Lixisol (FAO-Unesco, 1988) classification, and developed from granite. The soil is deep to moderate deep, well drained. Light to medium textured and is sandy loan. The mean physical and chemical properties of the surface soil (0-15 cm) at the beginning of the experiment is shown in (Table 1).

The treatment combinations were as follows: Control; 60-40-40 kg $NP_2O_5K_2O$ ha^{-1}; 4 tons of cowdung ha^{-1} ; 8 tons of cowdung ha^{-1}; 2 tons of cowdung + 30-20 -20 kg $NP_2O_5K_2O$ ha^{-1}; 4 tons of cowdung + 30-20-20 $NP_2O_5K_2O$ ha^{-1}; 4 tons of cowdung + 60-40-40 kg $NP_2O_5K_2O$ ha^{-1}; 8 tons of cowdung + 60 - 40 - 40 kg $NP_2O_5K_2O$ ha^{-1}.

The experinmental design was randomized complete block (RCB) with four replications. The plot size was 4 m × 10 m in long. The planting distance was 75 cm × 40 cm, and planted on ridges prepared with bullocks - a recommended practice in this ecological zone. The cowdung was applied with a hoe into the soil before ridging 2 weeks before planting. The full rate of P-fertilizer as single super phosphate at 40 kg ha^{-1}, K-fertilizer as muriate of potash at 40 kg ha^{-1}, and half rate of 30 kg ha^{-1} N-fertilizer as sulphate of ammonia were applied by hill placement method 2 weeks after germination. The other half rate of 30 kg ha^{-1} N-fertilizer was applied 5-6 weeks later by the same method of application. The treatments were repeated in the 1997 season. Composite soil samples per replication were taken before planting in 1996, and individual plots after harvest in 1997, and analysed by standard analytical methods (Page *et al.*,1982). The cowdung was also sampled for analysis before application. The maize cultivar used was Dorke S.R.

TABLE 1

Some Physical and Chemical Properties of the Surface (0-15 cm) Soil at Experiment Site at Manga Research Station, 1996

Soil properties	*Experimental site at Manga*
FAO-UNESCO Classification	Plinthic Lixisol
Sand (%)	80
Silt (%)	15
Clay (%)	5
Soil texture	Sandy loam
Soil *p*H ($CaC1_2$)	4.9
Organic carbon (%)	0.36
Total nitrogen (%)	0.018
Available P (mg kg^{-1})	15.6
Exchangeable cations cmol (+) kg^{-1})	
Ca	0.21
Mg	0.05
K	0.08
CEC [cmol (+) kg^{-1}]	1.90

Results and discussion

Soil fertility indices

Chemical analysis of the top 15 cm soil after harvesting showed increases of the mean *p*H, percentage organic carbon, available P and K of all treatments than the control (Table 2). As might be expected, the application of cowdung and NPK fertilizer resulted in the improvement of the chemical properties. The increase in *p*H may be due to the calcium content or the cowdung as NPK alone rather decreased the soil *p*H. The NPK content of the cowdung were total N(%) - 1.08%, available P (mg kg^{-1}) - 2554 and available K (mg kg^{-1}) - 1177. The increase of organic carbon, available P and K may be due to the release of nutrients especially N, P and K from the cowdung and the fertilizer. Similar results have been reported by several investigators (Bationo *et al.*, 1987; Dennis *et al.*, 1994; Olsen *et al.*, 1970).

TABLE 2

Effect of Treatments of Soil pH, Organic Carbon, Available Phosporus and Potassium after Two Years of Continuous Cropping

		1997		
	p*H*	*C*	*P*	*K*
Control	5.5	1.00	17 .27	20.54
60-40-40 NPK	4.7	1.05	18.99	23.13
4 tons of cowdung	5.4	1.11	15.56	44.49
4 tons of cowdung	6.1	1.19	20.28	47.35
2 tons of cowdung + 30-20- 20 NPK	6.0	1.13	24.67	25.49
4 tons of cowdung + 30-20-20 NPK	6.3	1.09	42.62	37.02
4 tons of cowdung + 60-40-40 NPK	5.1	1.09	30.53	34.46
8 tons of cowdung + 60-40-40 NPK	5.8	1.08	21.61	43.78
	4.9	0.36	15.6	32.4 (1996 results)

**pH ($CaCl_2$), org. C (%), available P and K (mg kg^{-1})

Crop yields

Yields obtained in 1996 were generally lower than those in 1997 (Table 3) due to poor rainfall distribution in the 1996 cropping season. However, fertilizer alone or in combination with cowdung significantly outyielded the control (stover and grain)in both years. This was due to the contribution of plant nutrients by the cowdung or the NPK fertilizers to the maize. Maize yield in 1997 was greater than that of 1996 due to increase in soil fertility status (Table 3) over the 2 years. Among the treat-ments in both years, 60-40-40 kg NPK ha^{-1} alone or in combination with 4 or 8 tons of cowdung ha^{-1} significantly increased both stover and grain yield of maize due to the positive effect of integrated nutrient (cowdung and inorganic fertilizer) on yield of maize. The cowdung × NPK fertilizers interaction was significant as compared to either the cowdung or fertilizer alone. This indicated the positive effect of integrated nutrient management for sustainable maize production in the interior savanna zone of Ghana.

TABLE 3

Effect of Cowdung and Minieral Fertilizer on Stover and Grain Yield (t ha^{-1}) of Maize (1996-1997)

	1996		*1997*	
	Stover	*Grain*	*Stover*	*Grain*
Control	0.69	0.10	0 .81	0.17
60-40-40 NPK	1.50	1.45	3.47	1.96
4 tons of cowdung	1.10	0.38	1.97	0.39
8 tons of cowdung	1.50	0.50	2.83	0.50
2 tons of cowdung + 30-20-20 NPK	2.90	0.96	3.00	1.11
4 tons of cowdung + 30-20-20 NPK	2.95	1.00	3.18	1.14
4 tons of cowdung + 60-40-40 NPK	1.85	1.55	4.22	2.24
8 tons of cowdung + 60-40-40 NPK	2.08	1.86	4.17	2.45
LSD (*P*=0.05)	0.55	0.42	0.57	0.30
CV (%)	14.0	16.2	13.4	16.5

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