Effect of enrichment and rate of cattle manure on nitrogen uptake and yield of tea

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Abstract
Tea (Camellia sinensis) is one of the most important cash crops in Kenya. The economic yield, two leaves and a bud are periodically harvested hence placing a lot of demand for the nutrients. Inorganic fertilizer NPK(S) 25:5:5:5 is generally recommended for the optimum supply of nutrients and crop yield. Non-judicious use of the inorganic fertilizer however acidifies the soil and pollutes the environment. Integrated soil fertility management, the combined use of organic and inorganic fertilizer, is recommended for improved crop yield and soil health. An experiment was carried out to determine the effect of enriching cattle manure with inorganic fertilizer 25:5:5:5s and varying the application rate on nitrogen uptake and yield of tea. Enriched and sole cattle manure up to a rate of 150kg N/ha increased the level of N in mature leaf. The N content in the mature leaf was highest under inorganic fertilizer NPKS 25:5:5:5 application. Enriching cattle manure with inorganic fertilizer significantly increased the crop yield.

Key words: cattle manure, enrichment, yield tea Camellia sinensis

Introduction
Tea (Camellia sinensis) one of the leading cash crops in Kenya can remain in production for up to 100 years. The regular harvesting of the crop (two leaves and a bud) however implies that nutrients are continuously mined from the soil. Nitrogen is one of the most important nutrients for tea production. A yield of 4000 kg made tea per ha removes about 160-200 kg N, 12-15 kg P₂O₅ and 84-100 kg K₂O from the soil (TRFK, 2010). Replacement of the lost nutrients is crucial for sustainable production of the crop.

In Kenya, a fertilizer rate of 100-200 kg N/ha in form of NPKS is recommended for optimal yield of tea. Many farmers use more than the recommended rates in a bid to realize high crop yield (Owuor et al., 2000). The high fertilizer rates are expensive, acidify the rhizosphere and pollute the water masses (Killpack and Buchholz, 1993). Continuous use of the inorganic fertilizer however threatens the sustainability of the system (Baruah et al., 2013). Cattle manure, one of the alternative nutrient sources is limited in quality and quantity (Gupta et al., 2004; Lekasi et al., 2001). Integrated soil fertility management (ISFM) the combined use of organic and inorganic fertilizers is recommended because of the synergistic effects that result in high crop yield and improved chemical, physical and biological soil conditions (Mishra et al., 1991; Vanlauwe et al., 2001). The benefits of ISFM have been demonstrated especially in the annual crop systems, but the challenge is how much, in what proportions and when the different fertilizer types are to be used. An experiment was carried out to determine the effect of enriched cattle manure rates on nitrogen uptake and yield of tea.

Material and methods
Site description
A field experiment was established in the year 2000 at Kangaita, Latitude, 0° 26’ S, Longitude 37° 15’ E, and altitude of 2020 m above sea level on the slopes of Mt Kenya at East of Rift Valley, Kenya. The soils are red clay classified as humic Acrisols (Kebeney et al., 2010).

Treatments
A high yielding clone TRFK 31/8 was used in the experiment. The treatments were included:
Inorganic fertilizer NPKS 25:5:5:5
Cattle manure
Enriched cattle manure (cattle manure: NPKS 25:5:5:5 at a ratio of 2:1)

Each of the treatments was applied at equivalent rates of 0, 75, 150 and 225 kg N ha⁻¹ year⁻¹. Cattle manure was sourced from the nearby farmers’ fields and standardized using the N content. The fertilizers were applied during the first week of September 2010 and 2011.

Experimental design
The trial was a 3 by 4 factorial experiment laid out in a Randomized Complete Block Design (RCBD) and replicated three times. Each plot was (10.98 by 5.46) m². The net plot comprised of (7 by 14) bushes spaced at (1.22 by 0.61) m².

Laboratory analysis
Cattle manure was ignited at 550°C and organic carbon determined by oxidation using concentrated sulphuric and potassium dichromate according to Nelson and Sommers (1975) and titrated against Ferrous ammonium sulphate. Nitrogen in the cattle manure was determined using Kjeldahl method by digestion using concentrated sulphuric acid with hydrogen peroxide as an oxidant and selenium as a catalyst at 330°C. Total nitrogen was then determined by distillation in the presence of sodium hydroxide then titration (Okalebo et al., 2002).

Nitrogen uptake
Leaf analysis has been used for a long time as a diagnostic tool in many perennial crops. Fifty mature leaves per net plot were sampled oven dried for 24 hours at temperature 105°C and milled using the coffee miller (Ramtons). Leaf Nitrogen was determined using Kjeldahl method by digestion using concentrated sulphuric acid with hydrogen peroxide as an oxidant and selenium as a catalyst at 330°C. Total nitrogen was determined by distillation in the presence of sodium hydroxide then titration. Total P was determined colorimetry with ammonium molybdate/ammonium vanadate mixture and p-nitrophenil as an indicator and K by the flame photometer (Okalebo et al., 2002).

Yield of tea
Tea was plucked at 7-10 days interval and the weight per plot recorded at every plucking round. The yields were converted to kg made tea per hectare per year (kgmt/ha/y) using the following equation: \( n \times a \times 0.225 \)/b. Where: \( n \) is green leaf yield per plot, \( a \) is plant population per hectare, 0.225 is the factor converting green leaf to made tea (TRFK, 2002) and \( b \) is the number of plants per plot.

Statistical analysis
Data was subjected to Analysis of Variance (ANOVA) using SAS version 9.0 statistical software package. Means were separated by Student- Newman-Keuls (SNK). Soil data with high coefficient of variations (CV) was transformed using loge (x +1).

Results and discussion
Nitrogen uptake
The N content in the mature leaf did not differ significantly with fertilizer type (Figure 1a and 1b). Kamau et al. (2008) and Kwach et al. (2012) noted comparable N content. The results show that of the N applied, less than 30% is recoverable in the mature leaf. The low amounts may be reason for the lack of significant difference. Moreover, irrespective of source, tea prefers the ammonium form of N (Li et al., 2013; Ruan et al., 2007) hence even when nitrate form applied it undergoes nitrification.

Fertilizer rate significantly increased the N content, especially at higher rates. Kamau et al. (2003) also noted an increase in N content in the mature leaf with increase in fertilizer rate. Increasing fertilizer rates under cattle manure resulted in lower N content compared to NPKS and enriched manures
probably because of the release of nutrients (Gupta et al., 2004). Enriched cattle manure resulted in increased the N content in mature tea leaf especially in 2011.

![Graph showing nitrogen content in mature leaf](image)

**Figure 1a:** Effects of fertilizer type and rate on the N content of the mature leaf in 2010

![Graph showing nitrogen content in mature leaf](image)

**Figure 1b:** Effects of fertilizer type and rate on the N content of the mature leaf in 2011

The results suggest that organic manure alone cannot supply adequate N for sustainable tea productivity.

**Crop yield**

Crop yield varied significantly with year, fertilizer type and rate (Figure 2). The annual crop yield variation is a common characteristic in tea where several factors including temperatures, amount and distribution of rainfall vary (Owour et al., 2008). In 2011 lower rainfall was received which resulted in lower yields compared to year 2010. The crop yield was thus generally higher in 2010 than in 2011. Cattle manure had the lowest yield probably because of the lower nutrient content. In 2010, inorganic fertilizer (NPKS) had the highest yield (3014 kg made tea/ha) followed by enriched cattle manure (2959 kg made tea/ha) and lastly cattle manure with 2572 kg made tea/ha. Enrichment increased crop yield by about 36%.
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Figure 2a: Effect of fertilizer type and rate on annual crop yield in 2010

Figure 2b: Effect of fertilizer type and rate on annual crop yield in 2011

In 2011, inorganic fertilizer (NPKS) had the highest yield (1661 kg made tea/ha) followed by enriched cattle manure (1604 kg made tea/ha) and lastly cattle manure with 1363 kg made tea/ha. Enriched manure had comparable yield to NPKS the positive control.

Crop yield increased with increasing fertilizer rate. The response of tea yield to the increase in N fertilizer rate has also been reported in several studies (Kamau et al., 2011; Wanyoko, 1997). The increase in yield with enriched manures is probably because of the effect on biological and physical soil properties that results in improved nutrient retention and nutrient release patterns and ultimately yield (Vanlauwe et al., 2001). The slow release of nutrients from cattle manure coupled with influence on pH and other properties maybe responsible for the low yields (Phukan et al. 2008). This shows that enriched manures can be used to substitute for inorganic fertilizers.

Conclusions

Use of organic manure resulted in higher P and K in the mature leaf. Although enriched manures showed lower K in the mature leaf, use of enriched manures resulted in higher, higher crop yield and P in the mature leaf. Enriched manures showed higher nitrogen uptake. Enriched manures can thus be used substitute the inorganic fertilizer (NPKS) enhanced tea production.

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Reference


