EFFECTS OF ORGANIC SOIL AMENDMENTS IN NUTRITION OF BANANA PLANTS

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ABSTRACT

Soil degradation is among the most common causes of low productivity of bananas in Kenya. Four organic soil amendments were evaluated at the Regional Research Centre at Embu during the 2006 long rainy season for their relative contribution to soil fertility in bananas. The amendments tested were: farmyard manure, poultry litter, *Tagetes minuta* and *Tithonia diversifolia.* A control treatment was also included in which no amendment was used. The treatments were arranged in a Randomized Complete Block Design replicated ten times. Ten tissue-cultured banana plants of the cultivar Grand Nain grown in polyethylene sleeves containing sterilized forest soil were used for each treatment. The amendments were incorporated in the soil at the rate of 5% (w/w) per plant. The study was conducted for a period of 90 days. Plant growth and soil fertility data were collected at the termination of the study. Plant growth data included plant height, pseudostem girth, number of leaves and plant biomass, which were analyzed using SAS. Residual soil fertility was determined through fertility analysis conducted at the National Agricultural Research Laboratories. Significant (P<0.05) improvements were observed in plant growth as well as residual levels of major soil nutrients in all amended soils. Poultry manure had the strongest influence on both parameters, showing increases of 54% and 190% in residual levels of nitrogen and phosphorous, respectively, compared to the control. Plant height, girth and total plant biomass increased by 26%, 42% and 46%, respectively over the control due to the application of this amendment. The results indicate that the organic soil amendments are suitable alternatives for restoration of soil fertility and have potential to improve banana productivity in small-holder farms when applied periodically.

Key words: Banana, Plant growth, Soil fertility, Organic amendments

INTRODUCTION

Banana ranks first among the horticultural crops in Kenya in terms of the total area under its production and income generation (Ministry of Agriculture, 2005). It is grown as a source of food, feed and cash income in most parts of the country, especially in Western, Nyanza, Coast, Central and Eastern provinces, thereby contributing considerably to food security and the

reduction of rural poverty in these regions. Bananas are mainly grown by small-holder farmers with little or no external fertilizer input and the bunch yields from these holdings are typically low (Qaim, 1999). Several factors, including the low inherent soil fertility in most banana producing areas and the invasion of destructive insect pests and diseases such as weevil borers, nematodes, panama and *Xanthomonas* wilt contribute to the low yields (Karamura, 2000). The continuous removal of banana bunches and pseudostems from orchards during harvesting, which is common in small-holder banana farming, results in a net drain on existing soil nutrients. This further exacerbates the soil degradation problem because such removal is not accompanied by the addition of external fertilizer inputs to replace the nutrients extracted by the harvested crop.

The removal of essential plant nutrients further diminishes the soil's ability to support strong plants which are capable of withstanding considerable pest pressure and produce high bunch yields. Banana production in the country is therefore characterized by rapid yield decline due to the absence of management inputs such as inorganic and organic fertilizers, irrigation, weed and pest control, which are practiced in commercial production systems (Robinson, 1996). Consequently, yields are one third of the potential production realizable under optimal management conditions (Qaim, 1999). Banana productivity may be significantly improved through use of external inputs such as inorganic fertilizers (Mbwana et al., 1998; Dosselaere et al., 2003) which are beyond the reach of many small-holder farmers in Kenya.

While available evidence shows that some of these materials may be useful in providing essential plant nutrients (Anonymous, 2003), previous studies on banana nutrition in Kenya have only focused on the use of inorganic fertilizers and cattle manure (Nguthi, 1998). Recent studies on organic materials have focused on their potential usefulness in the management of key banana pests (Musabyimana, 1999; Sundararaju and Kumar, 2003). There is therefore need to find suitable soil management alternatives for farmers which will enable them to improve banana productivity at affordable cost. Organic soil amendments have been shown to promote vigour and to slow yield decline in banana plants (Robinson, 1996). The objective of the present study was to evaluate the effectiveness of some commonly available organic materials in the management of soil fertility in banana farms.

MATERIALS AND METHOD

Experimental Design and Layout

A greenhouse-based trial was conducted over two seasons at KARI-Embu using tissue-cultured plants of the cultivar Grand Nain, one of the most

popular dessert bananas in the country. The experiment was laid out in a randomized complete block design (RCBD) with ten replications, comprising one plant per replicate. Post-flask plantlets were grown in 5 cm x 10 cm polyethylene sleeves containing steam-sterilized forest soil for a period of 2 months. They were later transferred to 15 cm x 22.5 cm polyethylene sleeves containing a mixture of forest soil and fine ballast in the ratio of 4:1 (v/v) and 5% (w/w) of one of the following organic amendments: composted cattle manure, poultry litter, *Tithonia diversifolia* or *Tagetes minuta.* The amendments were mixed thoroughly with the potting mix before the tissue-cultured plantlets were planted into the sleeves. The amendments of plant origin were harvested, chopped into small pieces and sun-dried for 2 weeks before application. A non-amended treatment was included as a control. The plantlets were transplanted into the larger polyethylene sleeves after attaining a height of 20 ± 2 cm. The plants were grown for a period of 90 days after amendment application after which the trial was terminated. Soil samples were randomly drawn from three replicates for determination of residual fertility.

Data Collection and Analysis

Plant height (plant base to axil of youngest leaf), pseudostem girth (20 cm from plant base), total leaf number and total plant biomass were determined at the end of the trial period. All the data were subjected to analysis of variance (ANOVA) using the SAS statistical package. Where significant treatment differences were detected, the means were separated using the Student-Newman-Keuls' (SNK) test at P=0.05. Soil fertility was analyzed at the National Agricultural Research Laboratories, Nairobi, Kenya.

RESULTS AND DISCUSSION

Effect of Amendments on Soil Fertility

There was a significant (P<0.05) improvement in the level of all macronutrients in all the amended soils compared with the unamended soil (Table 1). A significant improvement in the level of most micronutrients was also detected as a result of amending soils with different organic materials (Table 1). Poultry litter had the strongest influence on the levels of major soil nutrients, especially nitrogen and phosphorous, which were 54% and 190%, respectively, higher than the control. The second best amendment was *Tithonia diversifolia* with residual nitrogen, phosphorous and potassium levels of 13%, 54% and 104%, respectively, above the unamended soil. Robinson (1996) has cited many of the nutrients for which significant increases were observed as the most essential banana nutrients.

Table 1. Mean residual levels of major plant nutrients under different soil amendments

Amendment	C (%)	N (%)	P (%)	K (ppm)	Mg (me)	Mn (me)	Ca (me)	Fe (ppm)	C/N (ratio)
Control	4.83b	0.30d	98c	1.52c	6.4c	0.46b	28.9a	10.5a	16.1a
Cattle manure	5.48a	0.37c	128b	2.66a	7.3b	0.63a	32.2a	12.7a	14.8b
Poultry litter	5.47a	0.65a	284a	2.42ab	8.7a	0.39c	29.6a	9.8a	8.4d
T. minuta	5.54a	0.38c	126b	2.84ab	7.2a	0.70a	33.1a	10.8a	16.8a
T. diversifolia	5.41a	0.53b	128b	3.10a	7.4a	0.68a	33.4a	9.6a	10.2c
SE ±	0.18	0.03	11.42	0.12	0.21	0.05	0.23	0.31	0.49

Means within a column followed by the same letter are not significantly different at P=0.05, according to SNK test.

Bananas are also known to be a rich source of dietary minerals such as potassium, phosphorus, magnesium, calcium and iron (Mbwana et al., 1998) which are accumulated during plant growth. The differences in residual levels of different amendments may be attributed to variable levels of these minerals in the original plant material, which were not determined at the start of this study. However, the results indicate that the amendments are appropriate for use in banana soils because of their potential to improve levels of essential nutrients for the nutrition of the banana crop.

There was a significant reduction in the soil carbon to nitrogen ratio by amending it with other organic materials, except *Tagetes minuta* which tended to slightly increase this ratio above that of the control (Table 1). Poultry manure resulted in the highest reduction in this ratio (92%) followed by *Tithonia diversifolia* which reduced the ratio by 56%. The increase in the level of this fertility indicator by amending soil with of *Tagetes minuta* was as a result of slower decay of this amendment and the un-decomposed stem segments of which were clearly visible in the potting mixture at the end of the experimental period. The ability of some of the organic amendments to lower the carbon to nitrogen ratio is a positive attribute of the amendment in that it facilitates speedy nitrification and subsequent availability of nitrogen to the plant (Brady, 1984).

The results are consistent with the observations by other workers that in addition to supplying organic matter, organic soil amendments also supply useful amounts of essential nutrients for plant growth (Swift, 1997; Mugendi et al., 2001). The superior performance of poultry litter also concurs with the findings of other workers that it is the richest source of nutrients, especially nitrogen and phosphorous among animal-based manures (Brady, 1984; Everts et al., 2006). The general improvement in soil fertility is also important because the amendments would be useful in most banana-based cropping systems in Kenya, which have low inherent soil fertility (Jaetzold et al., 2006). The organic materials tested are available in most farming systems in Kenya either as weeds, hedge plants or by-products of livestock rearing systems. Although they may not supply large quantities of essential nutrients they, nevertheless, would be useful in banana nutrition.

Effect of amendments on plant growth

Plants grown in amended soils were significantly (P<0.05) taller than those grown in the un-amended control (Figure 1). The same effect was observed with respect to pseudostem diameter and whole plant biomass (Figure 1).

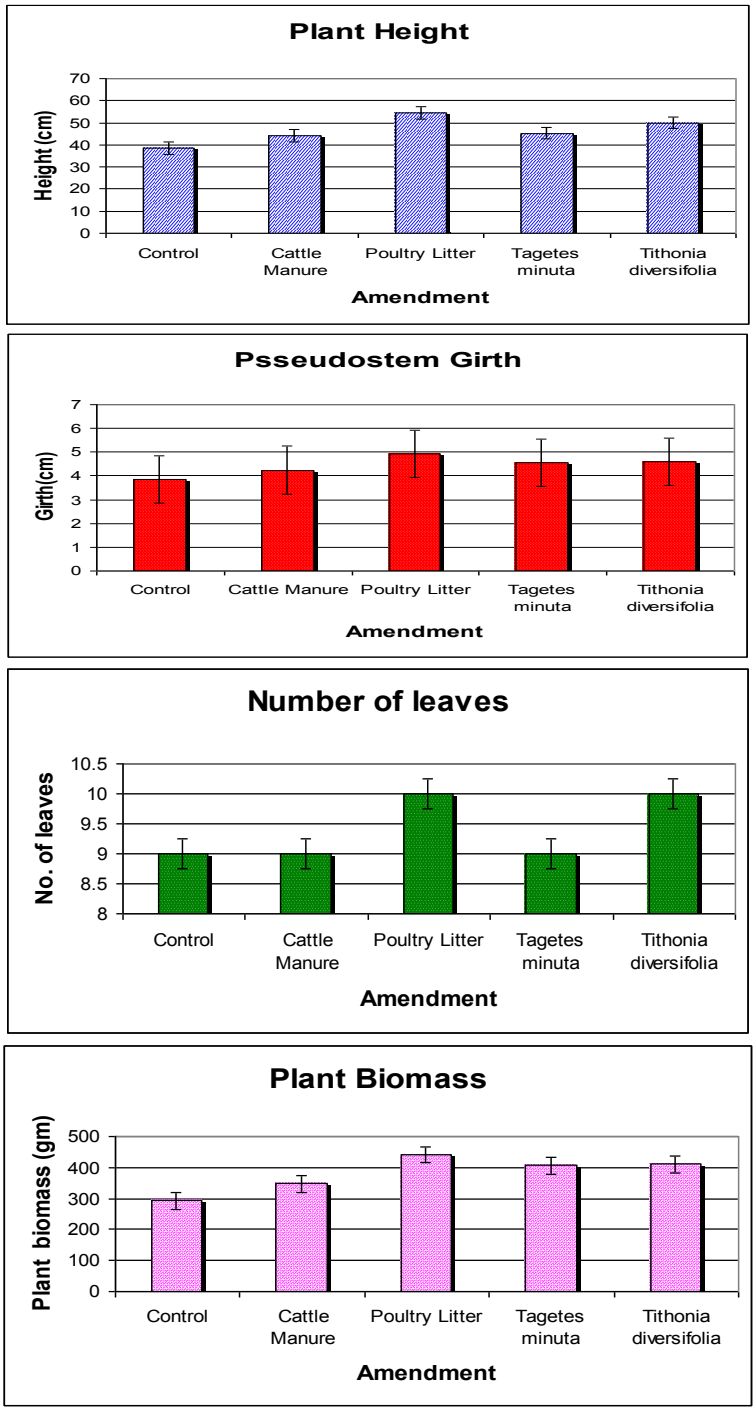

Figure 1. Mean plant growth indicators for soils amended with different organic materials

Plants grown in soils amended with poultry litter and *Tithonia diversifolia* had significantly (P<0.05) more leaves than the control and the other two amendments. Soils amended with poultry litter produced more superior plants with respect to all the growth parameters measured, followed by those amended with *Tithonia diversifolia, Tagetes minuta* and cattle manure. Application of poultry litter increased plant height, girth and total biomass by 26%, 42% and 46%, respectively, compared to the control (Figure 1).

The results indicate that there was a general improvement in plant vigour as a result of amendment use, especially the increases in plant height, girth and total biomass. These are consistent with the earlier findings that the amendments supplied essential nutrients for plant growth. The improved plant performance may therefore be attributed to the improvement of soil fertility by the amendments, some of which are known to be rich in nutrients (Brady, 1984; Anonymous, 2003). Bananas are also known to benefit greatly from nitrogen and phosphorous nutrition (Robinson, 1996).

Apart from their nutrient supply and ameliorative effects on soils, organic soil amendments have also been found useful in mitigating the effects of harmful banana pests and diseases (Bridge, 1996; Jonathan et al., 2000; Sundararaju and Kumar, 2003; Njeru et al*.,* 2006) water holding capacity and cation exchange capacity (Brady, 1984), among other benefits. This further underlines the potential of these amendments to imprive banana productivity in small-holder farming situations in Kenya.

CONCLUSION AND RECOMMENDATIONS

The rapid yield decline evident in small-holder banana orchards in Kenya has been mainly attributed to poor soil fertility, pest and disease pressure, which result from the failure to manage these problems using recommended fertilizers and appropriate pesticides. The lack of cash resources is often blamed for the failure to apply these inputs. However, the results from the present study show that some of the organic amendments commonly found in many farming systems, especially poultry litter and *Tithonia diversifolia* may be gainfully utilized to mitigate these problems.

Since the amendments supply very small amounts of essential nutrients compared to inorganic inputs, farmers are advised to apply them more frequently than the inorganic inputs. Field studies are currently on-going to determine the appropriate frequency of applying different amendments for improved banana productivity.

ACKNOWLEDGEMENT

We acknowledge the Director, KARI for providing financial support, the Centre Director for KARI-Embu for logistical support and all those who contributed in various ways to the success of this study.

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