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Role of *Casuarina equisetifolia* and *Melia volkensii* systems in Improving Soil Fertility in Coastal Kenya

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INTRODUCTION

Over 80% of Kenya's landmass is considered arid or semi-arid; characterized by erratic and inadequate rainfall and poor inherent soil fertility; this is coupled with other factors hampering agriculture development such as high cost of mineral fertilizer that many smallholder farmers cannot afford. Declining soil fertility is a major hindrance to agriculture development in Kenya. In most parts of the country, soils are deficient in nitrogen, phosphorus and in some cases potassium. Drought tolerant agroforestry trees are an important alternative for enhancing soil fertility to enable farmers meet nutrient demand in agricultural systems. The aim of the study was to determine the potential of *Casuarina equisetifolia* and *Melia volkensii* systems in soil fertility improvement in semi-arid coastal Kenya (Kwale and Kilifi Counties) for adoption by smallholder farmers to address soil fertility challenges. Casuarina and Melia are fast growing drought tolerant tree species that have widely been adopted in Coastal Kenya.

MATERIALS AND METHODS

Study Area

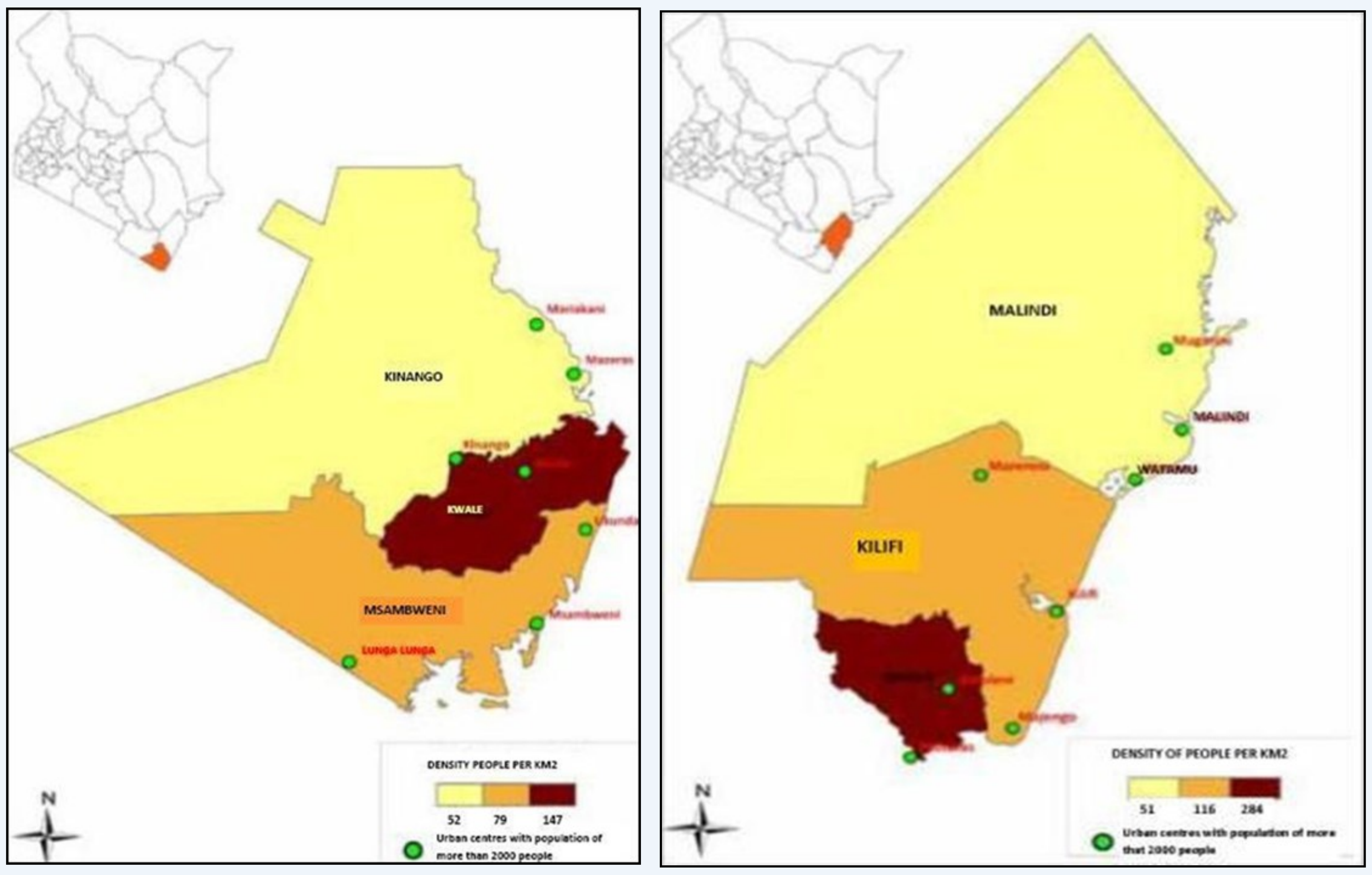
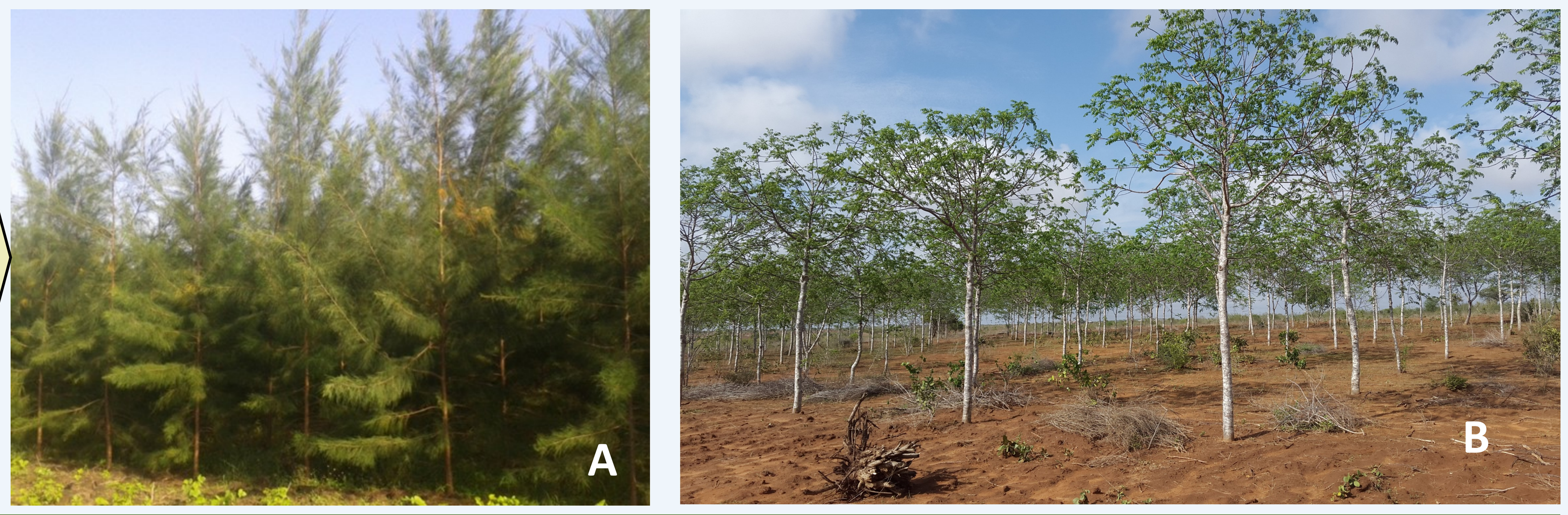


Figure 1: Maps showing study sites (Kwale and Kilifi Counties, Kenya)

Study Design

The experiment was set on-farm in a randomized complete block design with three treatments: Casuarina, Melia and control (pure maize crop stands) each replicated four times. Each plot measured 40m by 100m; with a spacing of 2m by 2m for Casuarina plots (with 1000 trees per plot) and 4m by 4m for Melia plots (with 250 trees per plot). Casuarina and Melia plots were intercropped with maize within the first two years. Soil fertility dynamics were evaluated from Casuarina, Melia and control plots two years after establishment for three consecutive years. Soil samples were obtained from depths of 0-20cm, 20-40cm and 40-60cm. Data was subjected to Analysis of Variance using GenStat software at 95% confidence level.

Figure 2: Casuarina (A) and Melia (B) woodlots used for the study



RESULTS AND DISCUSSION

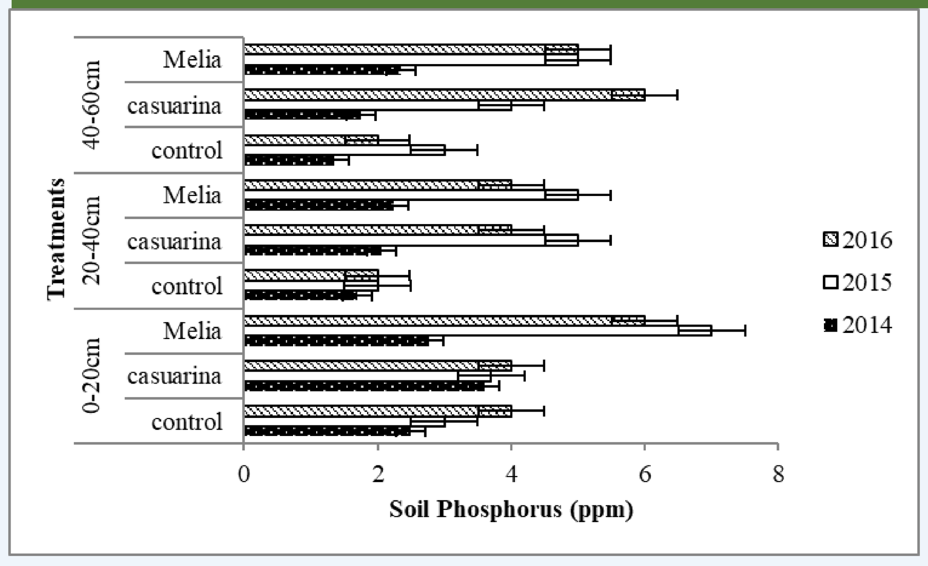


Figure 3: Soil Phosphorus under *C. equisetifolia* and *M. volkensii* at different sampling periods and depths

The concentration of Phosphorus decreased with depth along the soil profile. This can be attributed to P immobility in the soil. *Casuarina equisetifolia* and *M. volkensii* woodlots recorded the highest concentration of soil P. The concentration of available P increased with increasing age of the woodlots. *Casuarina equisetifolia* forms symbiotic relationship with mycorrhiza fungi that enhances P availability in the soil (Wielderholt and Johnson 2005 and Kandioura et al., 2013). Plots under Melia volkensii recorded the highest P concentration. This can be attributed to nutrient cycling by *M. volkensii* (Wielderholt and Johnson, 2005).

Generally Phosphorus (P) was low in all treatments (<11 ppm). This can be attributed to high soil pH. The form and availability of soil phosphorus is noted to be highly pH dependent and Phosphorus is most available at a pH of about 6.5 with moist and warm conditions. The soils under study had pH above the optimal range of 6.5. There was a positive correlation between soil pH and soil P across all treatments as illustrated in figures 4 and 5 (r^2=0.1777 and 0.3201 respectively). The increase in soil P was optimum at pH range of 6-7.

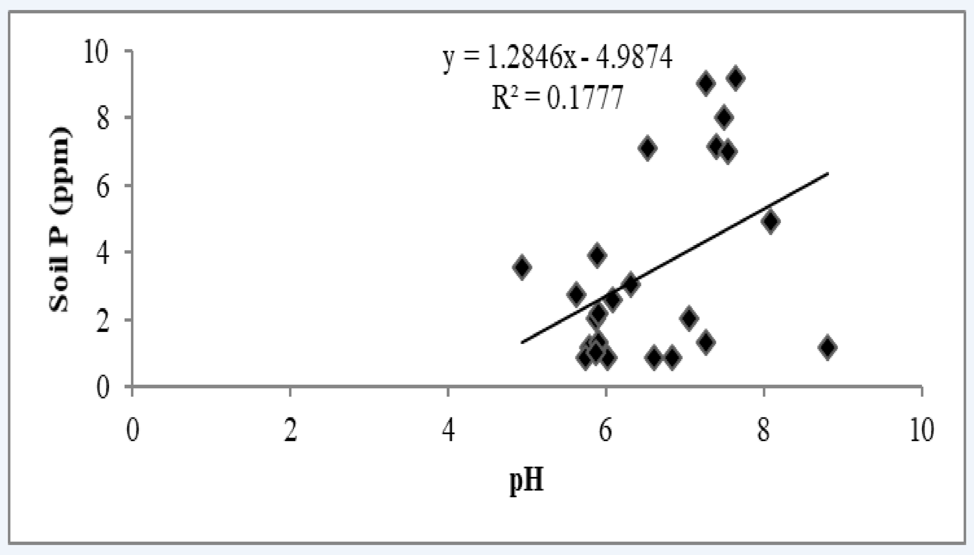


Figure 4: Correlation between soil pH and soil P in 2015 at 0-20cm sampling depth, in Kenya

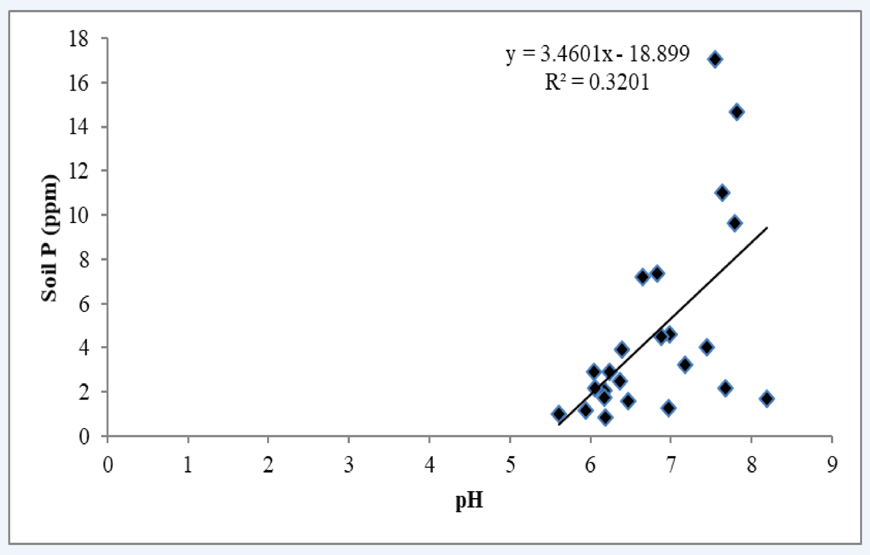


Figure 5: Correlation between soil pH and soil P in 2016 at 0-20cm sampling depth, in Kenya

Potassium concentration increased gradually in plots under Casuarina compared to the Melia plots and control treatments which recorded constant values in 2014, 2015 and 2016. The gradual increase in Potassium in Casuarina plots could be attributed to increase in litter fall under the canopies of C. equisetifolia (Belsky et al. 1989). The concentration was however higher in soils under M. volkensii and this could be attributed to the ability of M. volkensii to recycle nutrients from deeper soil layers (Mulatya et al., 2002).

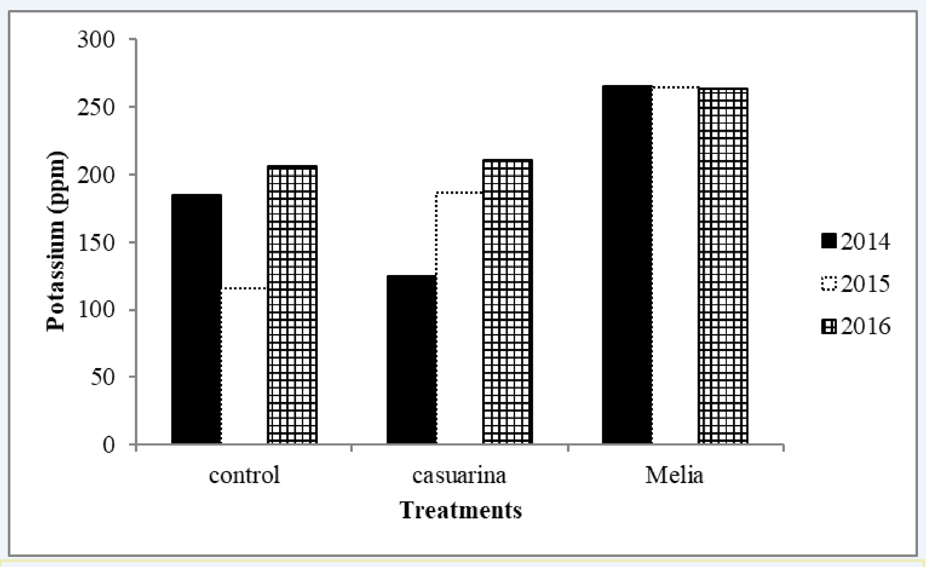


Figure 6: Soil Potassium under *C. equisetifolia* and *M. volkensii* at different sampling periods and depths

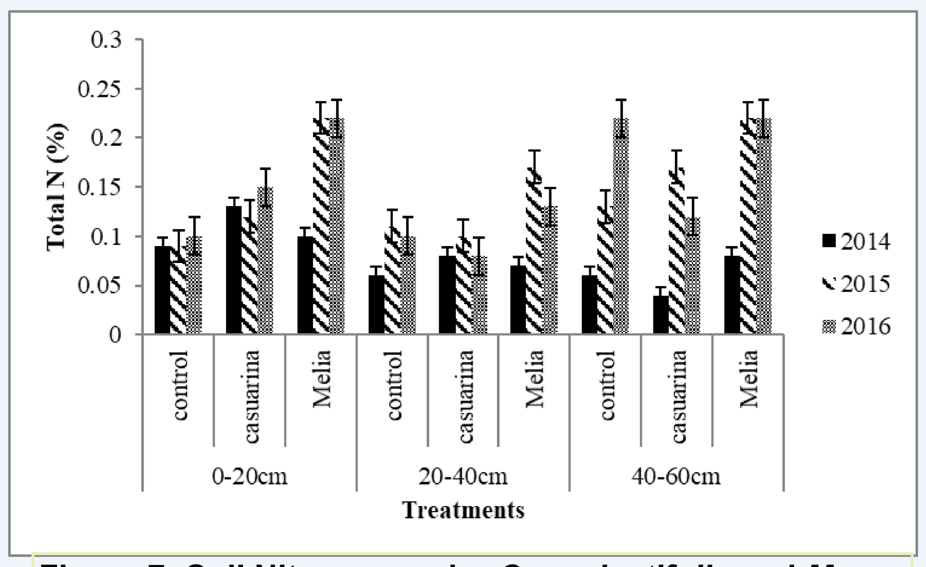


Figure 7: Soil Nitrogen under *C. equisetifolia* and *M. volkensii* at different sampling periods and depths

Total nitrogen increased gradually in the plots under *C. equisetifolia* and *M. volkensii* during the sampling period. Total nitrogen was higher in *C. equisetifolia* and *M. volkensii* plots compared to the control treatment. This could be attributed to the ability of *C. equisetifolia* to fix nitrogen through its symbiotic relationship with Frankia bacteria (Nambiar and Brown, 1997 and Ye *et al*., 2012) and ability of Melia to cycle nutrients from deep soil layers (Mulatya *et al*., 2002). The genetic make-up of plants, plant age, physical and chemical properties of soil greatly influence the population of Frankia bacteria to fix nitrogen (Pawlowski and Sirrenberg, 2003).

Table 1: Soil Carbon under *C. equisetifolia* and *M. volkensii* at different sampling periods and depths

Treatment	0-20cm			20-40cm			40-60cm		
	2014	2015	2016	2014	2015	2016	2014	2015	2016
Control	0.90±0.156[a]	0.37±0.018[a]	0.36±0.054[a]	0.57±0.101[a]	0.26±0.039[a]	0.26±0.044[a]	0.59±0.093[a]	0.20±0.032[a]	0.27±0.028[a]
Casuarina	1.26±0.202[a]	0.28±0.003[a]	0.38±0.074[a]	0.84±0.148[a]	0.23±0.045[a]	0.21±0.066[a]	0.45±0.118[a]	0.19±0.043[a]	0.29±0.042[a]
Melia	1.01±0.184[a]	0.38±0.033[a]	0.39±0.03[a]	0.73±0.124[a]	0.27±0.026[a]	0.26±0.036[a]	0.81±0.117[a]	0.21±0.03[a]	0.28±0.039[a]
	F(2,23)=1.01	F(2,23)=1.48	F(2,23)=0.12	F(2,23)=1.11	F(2,23) =0.23	F(2,23) =0.34	F(2,23)=2.75	F(2,23) =0.16	F(2,23) =1.00
	p =0.382 LSD =0.534	p =0.249 LSD=0.133	p =0.89 LSD=0.164	p =0.347 LSD=0.370	p =0.793 LSD=0.109	p =0.714 LSD=0.149	p =0.08 LSD=0.323	p =0.852 LSD=0.107	p =0.383 LSD=0.108

The soils were low in Carbon (<1.26%). However, *C. equisetifolia* plots recorded the highest Carbon content of 1.26% for top soil and 0.45% for sub-soil in 2014. Total C however declined in 2015 and 2016 sampling period. This can be attributed to the temperatures in 2015-2016 which could have accelerated decomposition of leaf litter. The amount of Soil Organic Carbon (SOC) depends on soil texture, climate and vegetation among other factors. Soil texture affects SOC because of the stabilizing properties that clay has on organic matter. Soils with high clay content therefore tend to have higher SOC than soils with low clay content under similar land use and climate conditions. Climate affects SOC amount as it is a major determinant of the rate of decomposition and therefore the turnover time of Carbon in soils (Milne, 2012).

CONCLUSION AND RECOMMENDATIONS

Results show a clear trend that *C. equisetifolia* and *M. volkensii* have potential to improve soil fertility. Plots under *C. equisetifolia* and *M. volkensii* recorded higher nutrient concentration than the control treatment. There is need to undertake the soil assessment for a long period of time to ascertain the existent trends in nutrient dynamics.

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