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## RESEARCH ARTICLE

# SUGARCANE RESPONSE TO LIMING, MANURING AND INORGANIC FERTILIZERS ON ACID ACRISOLS IN WESTERN KENYA

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**ABSTRACT**

Effects of agricultural lime, organic manure and selected inorganic fertilizers on sugarcane growth, yield and quality were determined in four trials conducted from 2009-2011 on acid acrisols in western Kenya. Predominantly grown sugarcane variety CO 945 was used in all experiments that were laid out in a randomized complete block design with three replications. The treatments comprised absolute control (no manure, no fertilizer), compost (18 t/ha), compost (18 t/ha+100 kg/ha diammonium phosphate (DAP) + 100 kg/ha Urea), standard practice (200 kg DAP + 200 kg Urea), agricultural lime (3 t/ha + 200 kg/ha DAP + 200 kg/ha Urea), agricultural lime (3 t/ha + 100 kg/ha DAP + 100 kg/ha Urea), Mavuno NPK (350 kg/ha + 200 kg/ha Urea) and Single Super Phosphate (SSP 450 kg/ha + 200 kg/ha Urea). Soil analysis results generally indicated low levels of pH, total nitrogen, phosphorus, potassium, calcium, magnesium, organic carbon and C.E.C in all sites. The soils were classified as acrisols with sandy clay, clay loam and sandy clay loam texture and high bulk density in all sites. Emergence, tillering, stalk number, height, inter-node length, cane and sugar yields differed significantly ($p \leq 0.05$) among the treatments in all locations. Higher cane and sugar yields were consistently recorded in treatments where agricultural lime and compost were included. There was no difference in yield between treatments that received full or half dose of the recommended Nor P along with the lime and compost amendments. Juice quality was highest in the SSP+Urea treatment ranging from 13.58 - 14.43 % Pol and lowest in the compost treatment ranging from 11.43- 13.37 % Pol. Smut incidence was notable in the compost and control treatments. Agronomic efficiency was highest in treatments where compost and agricultural lime were included, ranging from 90.3 to 481.5 kg sugarcane/kg nutrient. Highest net returns and value cost ratios were also recorded in treatments with compost and agricultural lime. Results of this study clearly demonstrated that utilization of agricultural lime and organic compost along with inorganic fertilizers improved sugarcane yield with potential benefits of reduced dosage of N and P to 50% of the local recommendation.



## INTRODUCTION

Sugarcane yield decline has plagued the sugar industry in Kenya over the last two decades. In the Mumias sugar zone (MSZ) that accounts for 50-60% of national production, average sugarcane yields declined by about 36% from a high of 110 t/ha in 1996 to a low of 69 t/ha in 2006. The yields declined further to only 51 t/ha compared with a world average of 64.4 t/ha (KSB, 2013). Sugarcane production in Kenya has happened over the last 60 years.

Growing of the crop on the same land is a common practice with no well defined breaks, rotations or fallow periods between the last ratoon and re-plant. Amounts and methods of fertilizer application largely remain the same with N-source being Urea and P-source diammonium phosphate (DAP). These fertilizers are acidifying and could have contributed to the observed decline in soil pH over the years (Wawire *et al*., 2007). Intensive mechanized tillage and infield cane loading and haulage operations in wet soil using heavy field equipment is done leading to soil compaction and stool damage. Severe soil compaction leads to high soil bulk density, low porosity, decreased water infiltration rate, water logging, poor root penetration and decreased crop yields (Muturi, 2010).

Sugarcane production systems worldwide have experienced yield decline associated with soil degradation caused by the long-term monoculture of sugarcane (Magarey *et al*., 1997). Studies from the Australian sugar industry have shown that old sugarcane land was degraded in chemical (Bramley *et al*., 1996; Skjemstad *et al*., 1995), physical (Ford and Bristow, 1995) and biological (Holt and Mayer, 1998; Pankhurst *et al*., 1996; Magarey *et al*., 1997) properties, with old land being more acid, having lower levels of organic carbon, lower cation exchange capacity, more exchangeable Al, more plant parasitic nematodes, more root pathogens, less microbial biomass, greater soil strength (more compacted) and lower water infiltration rate and storage capacity. It is argued that changes to the sugarcane production system that will address soil acidity, conserve organic matter, break the monoculture, control traffic and minimize tillage are the most appropriate ways to combat yield decline (Magarey *et al*., 1997).

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Research findings (Edwards and Lofty, 1982; Schjonning and Christensen, 1994) show that long-term addition of organic matter improves crop yield, water holding capacity, porosity, and water stable aggregation and decreases bulk density and surface crusting. Soil organic matter being an indicator of biological activity in the soil, provides substrate for the micro-organisms responsible for converting un-available plant and animal nutrients into forms that can be assimilated by plants (MSIRI, 2000). It has also been proved that soil organic matter is an essential component with key multifunctional roles in soil quality and related to many physical and biological properties of soil. The large organic matter returns with fertilizer addition can stimulate soil biological activity (Smith *et al*., 2000). Yadav *et al*. (2009) have observed that the old practice of applying large quantities of bulky organic manures like farm yard manure (FYM), green manure and organic waste material to sugarcane keeps on replenishing the soil with adequate quantities of micronutrients. The utilization of organic manures and other soil ameliorants like agricultural lime is known to be one way to replenish soil fertility. Agricultural lime increases the pH of acidic soil and provides a source of Ca for plants and permits improved water penetration for acidic soils. Liming also mitigates the effects of P fixation by Al and Fe oxides at low pH thus making the P available to sugarcane plants (NETAFIM, 2008). Liming is known to improve soil physical, chemical and biological activities resulting in better growth of crops (Davies and Payne, 1988; Haynes and Naidu, 1998).

acidic soils with low base status; they are strongly leached and are rich in Aluminum (Al) and Iron (Fe) Oxide elements that are responsible for nutrient fixation at low pH thus making the nutrients unavailable to plants (Jaetzold *et al*., 2005). Soil analysis results from the study sites at 0-30 cm and 30-60 cm are shown in Tables 1 and 2.

The treatments were laid out in a randomized complete block design (RCBD) with three replications. They comprised, control (no manure, no fertilizer), compost (18 t/ha), compost (18 t/ha +100 kg/ha DAP + 100 kg/ha Urea), agricultural lime (3 t/ha + 200 kg/ha DAP + 200 kg/ha Urea), agricultural lime (3 t/ha + 100 kg/ha DAP + 100 kg/ha Urea), Mavuno (350 kg/ha + 200 kg/ha Urea) and SSP (450 kg/ha + 200 kg/ha Urea). The chemical composition was SSP (20 % P), DAP (18 % N:46 % $P_2O_5$:0 $K_2O$), Urea (46 % N) and Mavuno NPK (10 % N:26 % $P_2O_5$:10 $K_2O$: 8% Ca, 4% Mg, 4% S ) as N, P and K source; organic compost (2.00 % N, 0.02 P % and 0.84 K %) and agricultural lime (Calcium hydroxide $Ca(OH)_2$ >36% and Calcium Oxide (CaO), >24% small quantities of Calcium Carbonate ($CaCo_3$), Magnesia (Mg) and trace elements). The net plot size for data collection was 1.5 m x 10 m x 4 rows = 60 $m^2$ at fields D 51 and A 1 and 1.2 m x 10 m x 4 rows = 48 $m^2$ at Musanda 22 and Khalaba 49 respectively, based on the recommended standard practice for spacing. Agronomic practices of weed management, top dressing with N, pest and disease observation were carried out as per the local recommendations (KESREF, 2006).

**Table 1** Soil chemical characteristics at the study sites

| | *pH (1:1)* | *Total N (%)* | *P Mehlich (ppm)* | *K (m.e)* | *Ca (m.e.)* | *Mg (m.e)* | *Ca/Mg ratio* | *CEC (%)* | *Org.C (%)* |
|---|---|---|---|---|---|---|---|---|---|
| *Field D 51* | 5.0 | 0.10 | 8.8 | 0.20 | 5.5 | 2.27 | 2.42 | 11.3 | 0.45 |
| *Musanda 22* | 4.7 | 0.12 | 25.5 | 0.30 | 1.0 | 1.07 | 0.90 | 10.1 | 1.28 |
| *Field A 1* | 5.4 | 0.10 | 19.8 | 0.40 | 3.5 | 1.83 | 1.91 | 10.4 | 1.05 |
| *Khalaba 49* | 5.2 | 0.12 | 27.9 | 0.30 | 2.1 | 1.01 | 2.08 | 8.5 | 1.39 |
| *Recommended** | 5.5 | > 1.0 | > 20 | > 0.7 | > 4.0 | > 2.0 | 2:1 | > 12.0 | > 2.0 |

Source : MSC Agronomy laboratory ; Key : SCL –sandy clay loam; CL - clay loam;
*for sugarcane (BSES,1994); Org. C- organic carbon; CEC- cation exchange capacity

Although some sugarcane growers have adopted the above practices in western Kenya, very little work has been done to quantify the effect on sugarcane. In addition, there are no studies done to determine the cost effectiveness and profitability of adopting these practices. The objectives of this study, therefore, were (i) to establish the effect of liming and manuring along with inorganic fertilizers on sugarcane growth, yield and quality and ii) to determine the agronomic efficiency and cost-effectiveness of various management options.

## RESULTS

### *Cane yield*

From the mean of four experiments, higher yields (23.1-25.3 t/ha above the absolute control and 5.8-8.0 t/ha above the standard practice) were recorded in treatments where organic compost and agricultural lime were included. There was no difference in yield between treatments that received full or half dose of the recommended N and P along .

**Table 2** Soil physical characteristics at the study sites

| *Site* | *depth (cm)* | *BD (g/cm³)* | *M.C (%)* | *Porosity (%)* | *Texture* | *Total rainfall (mm)* | *LTM (mm)* |
|---|---|---|---|---|---|---|---|
| *Field D 51* | 0-30 | 1.65 | 32.96 | 37.90 | SCL | 2909.2 | 2756.4 |
| | 30-60 | 1.85 | 24.64 | 30.30 | | | |
| *Musanda 22* | 0-30 | 1.46 | 35.55 | 44.50 | SCL | 2347.7 | 2535.6 |
| | 30-60 | 1.48 | 45.32 | 44.20 | | | |
| *Field A 1* | 0-30 | 1.66 | 27.74 | 36.10 | SC | 3147.1 | 2920.5 |
| | 30-60 | 1.72 | 36.40 | 33.80 | | | |
| *Khalaba 49* | 0-30 | 1.46 | 12.97 | 44.90 | SC | 2949.3 | 2937.0 |
| | 30-60 | 1.69 | 16.64 | 36.40 | | | |
| *Recommended** | | 1.10-1.40 | ≤ 50.0 | > 50.0 | | 1800-2500 | |

Source : KESREF field laboratory ; Key : SCL- sandy clay loam; CL- clay loam; BD – bulk density; MC – moisture content

## MATERIALS AND METHODS

The study was conducted from 2009-2011 in the Mumias sugar zone ($0^o$21'N and $34^o$ 30'E at 1314 m a.s.l). The zone receives bi-modal rainfall ranging from 1500-2000 mm per annum. The dominant soil type is orthic Acrisol (60%) followed by Ferralsol, Nitosol, Cambisol and Planosol (40%). Acrisols are

with compost or lime (Table 3). Utilization of organic compost and agricultural lime appeared to have ameliorated the soils as evidenced by improvement in the crop growth parameters namely tillering, stalk number, height and internode length (Table 4).

**Sugar yield, juice quality and fibre**

Sugar yield differed significantly ($p < 0.05$) among treatments. It was higher (2.2-3.0 t/ha above the absolute control and 0.4-1.2 t/ha above the standard practice) in treatments where organic compost and agricultural lime was applied (Table 3). Juice quality was highest in the SSP + Urea treatment followed by the lime + half dose of the recommended N and P but was lowest with compost manure alone. The high sugar yield recorded with compost was, therefore, a result of the increased sugarcane yield as opposed to improvement in juice quality. Fibre % cane was not different among the treatments except in the standard practice where it appeared to be higher (Table 3).

along with agricultural lime or compost manure (Table 7). The apparently high input cost for these particular treatments relative to the standard practice was mitigated by improved sugarcane yields hence higher gross and net returns. The treatment with agricultural lime and half dose of the recommended N and P had a marginally lower cost of fertilization yet it consistently recorded the highest cane and sugar yields hence being the most feasible recommendation economically.

## DISCUSSION

***Cane yield***

The higher yields recorded in the organic compost and

**Table 3** Effect of treatments on sugarcane yield and quality parameters

| Treatment | Cane yield (t/ha) | Sugar yield (t/ha) | Pol % cane | Fibre % cane |
|---|---|---|---|---|
| Control | 86.9$^{c}$ | 12.4$^{d}$ | 13.7$^{bc}$ | 17.1$^{b}$ |
| Compost (18 t/ha) | 110.0$^{a}$ | 14.6$^{bc}$ | 12.8$^{e}$ | 16.8$^{c}$ |
| Compost (18 t/ha) + 100 kg DAP + 100 kg Urea | 110.2$^{a}$ | 14.9$^{abc}$ | 13.3$^{d}$ | 17.0$^{bc}$ |
| Std practice 200 kg DAP + 200 kg Urea | 104.2$^{b}$ | 14.2$^{c}$ | 13.5$^{cd}$ | 17.3$^{a}$ |
| Lime (3 t/ha) + 200 kg DAP + 200 kg Urea | 110.7$^{a}$ | 15.0$^{ab}$ | 13.4$^{d}$ | 17.0$^{bc}$ |
| Lime (3 t/ha) + 100 kg DAP + 100 kg Urea | 112.2$^{a}$ | 15.4$^{a}$ | 13.8$^{ab}$ | 17.1$^{b}$ |
| 350 kg Mavuno + 200 kg Urea | 103.3$^{b}$ | 13.9$^{c}$ | 13.4$^{d}$ | 16.9$^{bc}$ |
| 450 kg SSP + 200 kg Urea | 101.8$^{b}$ | 14.3$^{bc}$ | 14.0$^{a}$ | 17.0$^{bc}$ |
| Mean | 104.9 | 14.3 | 13.5 | 17.0 |
| $LSD_{0.05}$ | 4.8*** | 0.7*** | 0.2** | 0.2* |
| CV % | 2.7 | 2.8 | 1.1 | 0.7 |

*p< 0.05; **p< 0.01; ***p< 0.001; ns- not significant using Fischer's least significant difference (LSD) procedure at 5 % level; means with the same superscript With in a column are not significantly different at p ≤ 0.05

**Table 4** Effect of treatments on selected sugarcane growth parameters

| Treatment | Tillers/ha('000) | Stalks/ha('000) | Stalkheight (cm) | Inter-node length (cm) |
|---|---|---|---|---|
| Control | 100.718$^{c}$ | 89.850$^{d}$ | 154.0$^{e}$ | 7.2$^{c}$ |
| Compost (18 t/ha) | 117.220$^{b}$ | 103.900$^{abc}$ | 170.7$^{abc}$ | 8.4$^{a}$ |
| Compost (18 t/ha) + 100 kg DAP + 100 kg Urea | 137.358$^{a}$ | 106.000$^{ab}$ | 166.3$^{cd}$ | 8.0$^{ab}$ |
| Std practice 200 kg DAP + 200 kg Urea | 123.903$^{b}$ | 99.475$^{c}$ | 167.7$^{bcd}$ | 8.1$^{a}$ |
| Lime (3 t/ha) + 200 kg DAP + 200 kg Urea | 136.970$^{a}$ | 106.775$^{ab}$ | 173.3$^{a}$ | 8.0$^{ab}$ |
| Lime (3 t/ha) + 100 kg DAP + 100 kg Urea | 124.308$^{b}$ | 108.225$^{a}$ | 172.0$^{ab}$ | 8.2$^{a}$ |
| 350 kg Mavuno + 200 kg Urea | 136.270$^{a}$ | 100.850$^{bc}$ | 167.9$^{bcd}$ | 8.1$^{a}$ |
| 450 kg SSP + 200 kg Urea | 118.548$^{b}$ | 97.650$^{c}$ | 163.7$^{d}$ | 7.6$^{bc}$ |
| Mean | 124.410 | 101.575 | 166.9 | 7.9 |
| $LSD_{0.05}$ | 10.178*** | 6.433*** | 5.2*** | 0.4* |
| CV % | 5.025 | 3.925 | 2.0 | 2.2 |

*p< 0.05; **p< 0.01; ***p< 0.001; ns- not significant using Fischer's least significant difference (LSD) procedure at 5 % level; means with the same superscript With in a column are not significantly different at p ≤ 0.05

**Agronomic efficiency (AE)**

Agronomic efficiency ranged from 75.4-253.3 and 8.3-32.6 for cane and sugar yield respectively. Higher AE was indicated in the treatments where N and P were applied along with agricultural lime and compost manure (Table 5 and 6). This suggested better availability and utilization of nutrients when the soil ameliorants were applied. Lowest AE was recorded in the Mavuno NPK + Urea treatment suggesting that that this treatment had a low yield to nutrient ratio.

agricultural lime treatments could be attributed to amelioration of the soils as evidenced by improvement in the crop growth parameters namely tillering, stalk number, height and inter-node length. This result was consistent with that of many others. Yadav *et al*. (2009) found out that application of limestone at 1-3 t/ha to the plant crop in acid soils of Thiruvella, Kerala, India improved the yield and juice quality of subsequent ratoons.

**Table 5** Agronomic efficiency of the treatments on sugarcane yield per ha

| Treatment | Y | YI | % | AE |
|---|---|---|---|---|
| Control | 86.9 | - | - | - |
| Compost (18 t/ha) | 110.0 | 23.1 | 26.6 | 198.2 |
| Compost (18 t/ha) + 100 kg DAP + 100 kg Urea | 110.2 | 23.3 | 26.8 | 253.3 |
| Std practice 200 kg DAP + 200 kg Urea | 104.2 | 17.3 | 19.9 | 93.9 |
| Lime (3 t/ha) + 200 kg DAP + 200 kg Urea | 110.7 | 23.8 | 27.4 | 129.5 |
| Lime (3 t/ha) + 100 kg DAP + 100 kg Urea | 112.2 | 25.3 | 29.1 | 275.3 |
| 350 kg Mavuno + 200 kg Urea | 103.3 | 16.4 | 18.9 | 75.4 |
| 450 kg SSP + 200 kg Urea | 101.8 | 14.9 | 17.1 | 81.7 |

Y= Yield, YI= Yield increase over control, AE =agronomic efficiency (kg sugarcane/kg nutrient)

**Economic evaluation**

Consistently high value cost ratios (VCRs) and net returns were indicated in the treatments where N and P was applied

Soon and Arshad (2005) found a significant increase in crop yield and soil labile N pools due to liming with zero tillage compared to liming with conventional tillage. In Buralikson

Assam, India, liming at 2 t/ha along with P application on a clay loam soil with pH 4.8 significantly increased cane yield by 5.2 to 16.9% over the control (Singha, 2006). In North Carolina, USA (Colleen, 2004) reports that agricultural lime increased fertilizer use efficiency, concluding that money spent on fertilizer is not well invested unless soil pH is properly adjusted first. In South Africa, high pH values, low Al, Na and high levels of P are reported to be associated with high sugarcane yielding points (Antwerpen *et al.,* 2007). In Malaysia, liming of sugarcane on acid latosols and lateritic latosols increased cane tonnage by about 10 t/ha principally through increases in the production of millable stalks as well as increases in stalk length and internode number (Leong, 1980 ). Other reports (Edwards and Lofty, 1982; Schjonning and Christensen, 1994) show that long-term addition of organic matter improves crop yield, water holding capacity, porosity, and water stable aggregation and decreases bulk density and surface crusting. In Ethiopia, Abreha Kidanemariam *et al.* (2013) found out that yield and yield attributes of wheat showed significant response to the main effects of lime and fertilizer applications. Fertilizer × lime interaction effect was significantly different in grain yield, total biomass and N and P uptake.

**Table 6** Agronomic efficiency of the treatments on sugar yield per ha

| Treatment | Y | YI | % | AE |
|---|---|---|---|---|
| Control | 12.4 | - | - | - |
| Compost (18 t/ha) | 14.6 | 2.2 | 17.7 | 18.9 |
| Compost (18 t/ha) + 100 kg DAP + 100 kg Urea | 14.9 | 2.5 | 20.2 | 27.2 |
| Std practice 200 kg DAP + 200 kg Urea | 14.2 | 1.8 | 14.5 | 9.8 |
| Lime (3 t/ha) + 200 kg DAP + 200 kg Urea | 15 | 2.6 | 21 | 14.1 |
| Lime (3 t/ha) + 100 kg DAP + 100 kg Urea | 15.4 | 3 | 24.2 | 32.6 |
| 350 kg Mavuno + 200 kg Urea | 13.9 | 1.8 | 14.5 | 8.3 |
| 450 kg SSP + 200 kg Urea | 14.3 | 1.9 | 15.3 | 10.4 |

Y= Yield, YI= Yield increase over control, AE =agronomic efficiency (kg sugarcane/kg nutrient)

**Table 7** Economic evaluation of liming and OM application on sugarcane yield

| **Treatment** | **Yield (t/ha)** | **GR(Ksh)** | **FC(Ksh)** | **NR(Ksh)** | **VCR** |
|---|---|---|---|---|---|
| Control | 86.9 | 325,875 | - | 325,875 | - |
| Compost (18 t/ha) | 110.0 | 412,500 | 27,000 | 385,500 | 14.28 |
| Compost (18 t/ha) + 100 kg DAP + 100 kg Urea | 110.2 | 413,250 | 40,714 | 372,536 | 9.15 |
| Std practice 200 kg DAP + 200 kg Urea | 104.2 | 390,750 | 27,428 | 363,322 | 13.25 |
| Lime (3 t/ha) + 200 kg DAP + 200 kg Urea | 110.7 | 415,125 | 39,833 | 375,292 | 9.42 |
| Lime (3 t/ha) + 100 kg DAP + 100 kg Urea | 112.2 | 420,750 | 26,119 | 394,631 | 15.11 |
| 350 kg Mavuno + 200 kg Urea | 103.3 | 387,375 | 34,940 | 352,435 | 10.09 |
| 450 kg SSP + 200 kg Urea | 101.8 | 381,750 | 38,390 | 343,360 | 8.94 |

GR= Gross return; FC= Fertilizer cost; NR= Net return; VCR= Value cost ratio; Price of DAP = Ksh 3,897; SSP = Ksh 2950; Urea = Ksh 2,960; Mavuno = Ksh 3,300 per 50 kg bag; Agricultural lime = Ksh 4,135 per ton; Price of sugarcane= Ksh 3,750 per ton; 1 US$= Ksh 85

### Sugar yield, juice quality and fibre

The result agreed with that of Singha (2006) suggesting that application of lime increased the quality of juice by increasing the sucrose and decreasing the glucose content of cane juice caused by enhanced maturity. It was also in agreement with findings from Malaysia (Leong, 1980) where liming of sugarcane on acid latosols had no effect on the fibre content. However, a study in S. Africa (Meyer, 1976) contradicts this finding by reporting that in one trial on a high N mineralizing soil, lime treatments significantly depressed sucrose % cane from an average of 13.4 % in the control to 12.4 % in the lime treatment. The decline was accompanied by a general increase in foliar-N values in excess of 2.5 %.

### Agronomic efficiency

This finding agreed with studies in North Carolina, USA which showed that agricultural lime increased fertilizer use efficiency (Colleen, 2004). It also agreed with Kidanemariam *et al.* (2013) who found out that yield and yield attributes of wheat showed significant response to the main effects of lime and fertilizer applications.

## CONCLUSION AND RECOMMENDATION

The results of this study established the significance of agricultural liming and utilization of organic manures along with recommended NP fertilizers for better sugarcane growth, higher cane and sugar yields, higher agronomic efficiency and higher farmer profitability in MSZ. It is recommended that the soil ameliorants be included in the fertilization regime at Mumias especially in places where soil analysis results show low organic carbon fraction. The current recommendation for N and P could be retained along with liming or manuring; however, cost savings could be made since crop yield was not different when half dose of the recommended N and P was used along with agricultural lime or organic manure. Agricultural lime could also be adopted on high P response soils.

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## References

Antwerpen T Van, Antwerpen R Van, Meyer J H, Naido P, Berry S, Spaull VW, Govender K, Cadet P, Rutherford S and Laing M 2007. Factors associated with a healthy soil in sugarcane production in Kwazulu Natal. *Proc. Int. Soc. Sugarcane Techno. 28: 273-279.*

Bramley RGV, Ellis N, Nable RO and Garside AL 1996. Changes in soil chemical properties under long term sugarcane monoculture and their possible role in sugarcane yield decline. *Aust. J. Soil Res.,* 34: 967 - 84.

Colleen HW 2004. Crop Fertilization based on North Carolina Soil Tests. NCDA & CS Agronomic Division North Carolina Department of Agriculture and Consumer Services *www.ncagr.gov/agronomi/* (919) 733-2655.

Davies, DB, Payne, D 1988. Management of soil physical properties. In: Wild (Eds.), Russell's Soil Conditions and Plant Growth. 11th ed. Longman, Harlow, Essex, pp. 412–448

Edwards CA and Lofty JR 1982. Nitrogenous fertilizers and earthworms populations in agricultural soils. Soil Biol. Biochem. 147, 515–521.

Ford EJ and Bristow KL 1995. Soil physical properties of several sugar producing soils in north Queensland. II. Soil moisture retention, bulk density, and particle size distribution. *CSIRO Div Soils, Tech. Rep*. 7/1995.

Haynes, R.J., Naidu, R., 1998. Influence of lime, fertilizer and manure applications on soil organic matter content and physical conditions: a review. Nutr. Cycling Agroecosyst. 51, 123-137.

Holt, J.A. and Mayer, R.J. (1998). Changes in microbial biomass and protease activities of soil associated with long term sugarcane monoculture. *Biology and Fertility of Soils* 27: 127-131.

Jaetzold R, Schmidt H, Hornetz B and Shisanya C 2005. Ministry of Agriculture. Farm Management Handbook of Kenya Vol. II- Natural Conditions and Farm Management Information 2nd edition. Part A West Kenya (Subpart A1-Western province), pp 36-38.

Kenya Sugar Board 2013. Year Book of Statistics pp 8-39.

Kenya Sugar Research Foundation 2006. Technical Bulletin No. 1., pp 55-105 Copyright © 2006. ISBN: 9966-7179-1-9.

Kidanemariam A, Gebrekidan H, Tekalign M and Tesfaye K 2013. Wheat crop response to liming materials and N and P fertilizers in acidic soils of Tsegede highlands, Northern Ethiopia. Agriculture, Forestry and Fisheries. 2 (3):126-135

Leong 1980. Management of Acid Sulphate Soils in the Muda Irrigation Scheme, Kedah Peninsular, Malaysia. Xaviar Arulandoo Rice Research Branch, Mardi Kam Suan Pheng, University Sains Malaysia, PENANG.

Magarey RC, Bull JI, Blair BL and Johnson EJ 1997. Biological studies of soils in paired old and new land sites growing sugarcane. *Aust. J. Exp. Agric*. 37: 451 - 457.

Meyer JH 1976. Some observations on foliar nitrogen and sucrose levels in sugarcane. Unpublished report, Midlands Project, File 8.1.6, Folio 61

NETAFIM, Worldwide 2008. Sugarcane: www.sugarcanecrops.com

Pankhurst CE, Blair BL, Magarey RC, Stirling GR and Garside AL 1996. Effects of biocides and rotation breaks on soil organisms associated with the poor early growth of sugarcane in continuous monoculture .*Journal of Plant and Soil, pp 255-269.*

Schjonning P and Christensen BT 1994. Physical and chemical properties of a sandy loam receiving animal manure, mineral fertilizer or no fertilizer for 90 years. Eur. J. Soil Sci. 45, 257–268.

Singha DD 2006. Effect of liming on the sugarcane (*Saccharum officinarum*) yield, juice quality and available soil nutrients in acid soil. Vol 76, No 3 (2006).

Skjemstad JO, Taylor JA and Janik LJ 1995. Establishing organic matter base-line data on Yield Decline Joint Venture sites. *CSIRO Div. Soils, Adelaide, Report to SRDC.*

Smith OH, Petersen GW and Needleman BA 2000. Environmental indicators of agro ecosystems. Adv. Agron. 69, 75–97.

Soon, YK and Arshad, MA 2005. Tillage and liming effects on crop and labile soil nitrogen in an acid soil. Soil Tillage Res. 80, 23–33.

Wawire NO, Nyongesa DP and Kipruto KB 2007. The effect of continuous land subdivision on cane production in Kenya. *KESREF-Technical Bulletin 1 (2):54-71.*

Yadav RL, Yadav DV and Shukla SK 2009. Improving Yield and Quality of Sugarcane through Secondary and Microntrients. Indian J. Fert., Vol. 5 (4), pp. 99-105.

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