Impact of Conservation Agriculture on Soil Properties and Maize Grain Yield in the Semi-Arid Laikipia County, Kenya

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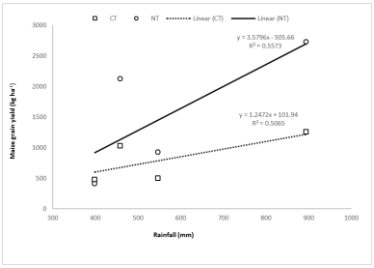
Introduction

Low and unreliable rainfall, along with poor soil health, is a main constraint to maize production in the semi-arid parts of Kenya. In the semi-arid County of Laikipia, farmers continue to plant maize despite the low rainfall. Participatory farmer experimentation with Conservation Agriculture (CA) was undertaken for six consecutive growing seasons between July 2013 and December 2016 to determine the effectiveness of CA as a method of improving soil properties and enhancing maize yields with the limited rainfall in the region. The main CA practices tested included chisel tine furrow opening (ripping), live legume (*Lablab purpureus*) cover crop as well as maize stover mulches all implemented under varying inorganic fertiliser rates. The research was done across 12 administrative locations of the County whereby soils are mainly *Phaeozems* and *Vertisols* with clay-loam texture. The research design used was researcher-designed and farmer-managed. In each of the 12 trial sites, participatory farmers' assessments and field days were carried out as a way of outreach to the bigger farming communities around the trial sites. The research findings obtained demonstrated that the use of CA impacts positively on soil properties and is a viable practice for enhancing maize yields in these moisture deficit parts of the country. Soil chemical analysis results showed CA impacted positively on some soil mineral components namely organic carbon, total nitrogen, phosphorus, potassium, calcium and pH. Mid-season chlorophyll content assessment of the maize crop showed that there was good response to fertilizer application as well as mulching with crop residues for soil cover. Maize grain yield data also showed that the use of CA package comprising chisel tine ripping combined with mulching by plant residues and use of mineral fertilizer resulted in a two-to-three-fold increase in grain yields above the farmer practice control. Mean maize grain yield in farmer practice plots was 1,067 kg ha^{-1} compared with the CA treated plot with mineral fertilization that yielded 2,192 kg ha^{-1}.

Mulched plot of Treatment 6 (mulch+ fertilizer+CA) in Margaret Wangui's demo plot in Wiyumiririe, Laikipia

Table 1: Maize yield (kg ha^{-1}) of Conventional Tillage and CA treatments from 2014 to 2016

Treatment \ Season	LR 2014	SR 2014	LR 2015	SR 2015	Mean
Annual rainfall (mm)	398.1	546.4	458.4	894.5	
Conventional Tillage	480	502	1,033	1,258	818
CA	416	929	2,124	2,732	1,550



Correlation between grain yield and rainfall from 2014 to 2016

CA is considered to be an essential climate smart basis for production systems that enhance crop and livestock production, livelihoods and quality of life under the African Union's Malabo Declaration and Agenda 2063 as well as the Vision 25 x 25, of having 25 million households practicing climate smart agriculture in Africa by 2025.

Conservation Agriculture (CA) is a method of managing agro-ecosystems for improved and sustained productivity, increased profits and food security while preserving and enhancing the resource base and the environment. CA provides environmental services such as contributing to atmospheric carbon sequestration, preserving biodiversity, managing watersheds and preventing soil erosion. It has the potential to support crop production under tropical conditions while mitigating natural resource degradation.

Methodology and Results

Laikipia County lies between latitudes 0°18" and 0°51" North and longitude 36°11" and 37°24' East. The altitude varies between 1,500 m above sea level in the North and 2,611 m in the South. It receives an annual rainfall 300 to 750 mm. Agriculture is the dominant economic activity. Majority of residents keep livestock and grow different food crops such as maize, wheat, potatoes, as well as horticultural crops.

The project used the Mother-Baby trial design. In Mother-Baby Trial Design**,** the "mother" trials (numbering 12) were testing the full set of six CA treatments to demonstrate CA and ISFM practices aimed at improving the productivity of maize. The test crop in this experimentation was maize while Lablab was intercropped with maize to act as the cover crop. The main crop was planted at the onset of the rains and the cover crop two weeks later. Each plot measured 10 m long and 10 m wide. Maize was fertilized with 60 kg N ha^{-1}+20 kg P_2O_5 ha^{-1}. Lablab was planted in rows between the maize rows as follows: one row and hill to hill spacing of 50 cm (2 seeds) for Lablab.

The maize data collected included stand count, plant height as well as grain and stover yields. Legume weight assessments proved more difficult due to the indeterminate nature of the variety used. Initial soil characterization was done prior to the initial planting in all treatment sites. Soil chemical properties were determined after the final season of experimentation to assess the effect of various treatments on the soil chemical characteristics. Results of evaluation of soils at the start in 2013 and at the end of the trials in 2016 showed that CA practices had positive influence on a number of soil mineral components including organic carbon, total nitrogen, phosphorus, potassium, calcium and pH. In this study, there were clear moisture conserving effects by residue mulch coupled with fertilization effects in the full CA treatment. Mean maize yield for CA was 89.5% greater than that for conventional tillage over all seasons, and yield differences were significant in all the years ($P < 0.05$) after the first year. There was a strong positive correlation between the rainfall and maize yields in CA plots (R^2=0.557) compared to the plots with conventional tillage treatment (R^2=0.507).

Conclusion

These findings have demonstrated that in order to reap maximum benefits, farmers need to complement CA with mineral nutrient inputs, for soil fertility recuperation given the fact that the smallholder farms in this County have depleted nutrient stocks due to years of nutrient mining and tillage. Data collected over three seasons of consecutive cropping indicate that the use of CA package of minimum soil disturbance and mulching with plant residues, complimented with use of mineral fertilizer resulted in a 105 per cent increase in maize grain yields above the farmer practice of conventional tillage without fertilisers, and an increase of 49% when inorganic fertilisers are used under conventional tillage.

The farmers' uptake of CA was observed to be dependent on individual farmer situations like gained knowledge levels, innovativeness and traditional beliefs. Most farmers were fast in adopting the reduced tillage and gradually the soil cover. With better harvests and diversification through incorporation of cover crops the farmers were able to gradually leave substantial residues overtime for soil cover. To enhance further uptake and scaling up of CA, regular capacity building and backstopping of farmers is essential to address new challenges likely to arise with time.