Research Application Summary

Yield and rain water use efficiency of maize (*Zea mays* L.) under selected soil and water conservation technologies in the central highlands of Kenya

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Abstract

A study was carried out to assess the effectiveness of mulching, mbili intercrop, minimum tillage and tied ridging on soil and water conservation and improvement of maize yields under a rainfed farming system. The treatments, in three replicates, were laid out in a randomised complete block design on 2% slope runoff plots on a Nitisol in the sub humid region and a Cambisol in the semi-arid region of the central highlands of Kenya. Data on grain yield, soil properties, sediment, runoff and soil moisture were subjected to analysis of variance (ANOVA) using SAS 9.1.3. Results indicated highest maize grain yield of 4.9 Mg ha^{-1} under mbili intercrop followed by mulching (4.4 Mg ha^{-1}). Minimum tillage resulted into the lowest (4.0 Mg ha^{-1}) yield in the sub humid region. In the semi-arid region, weather variability characterised by meteorological dry spells occurred during the LR11 cropping season leading to total crop failure. During SR11/12, mulching and tied ridging were averagely the best with yields of 1.3 Mg ha^{-1} and 1.1Mg ha^{-1}. Mbili intercrop and conventional treatments had 0.1 Mg ha^{-1} and 0.7 Mg ha^{-1}, respectively. At the sub humid region, mulching, minimum tillage and mbili intercrop reduced sediment loss by 47%, 33% and 4% respectively compared to the control. In the semi-arid region, mulching, tied ridging and mbili intercrop reduced soil sediment loss by 65%, 48% and 39%, respectively compared to the control. Runoff was not significantly influenced by treatments in both experimental sites and was generally in the decreasing order of minimum tillage, control treatment, mbili intercrop and mulching in sub humid region; and control treatment, mbili

intercrop, mulching and tied ridging at semi-arid region. Soil nutrients improved remarkably with the conservation strategies.

Key words: Central highlands of Kenya, rain water use efficiency, soil and water conservation technologies, *Zea mays* L.

Résumé

Une étude a été menée pour évaluer l'efficacité du paillage, de la culture intercalaire mbili, du labour minimum et du billonnage cloisonné sur la conservation des sols et de l'eau et l'amélioration des rendements du maïs dans un système d'agriculture pluviale. Les traitements, en trois répétitions, ont été énoncés dans un dispositif en blocs aléatoires complets sur des parcelles de ruissellement de pente de 2% sur un *Nitisol* dans la région sous-humide et sur un *Cambisol* dans la région semi-aride des hauts plateaux de centre du Kenya. Les données sur le rendement en grain, les propriétés des sols, les sédiments, les eaux de ruissellement et l'humidité du sol ont été soumises à une analyse de la variance (ANOVA) en utilisant SAS 9.1.3. Les résultats ont indiqué un plus haut rendement en grains du maïs de 4,9 Mg ha^{-1} sous la culture intercalaire mbili suivie par le paillage (4,4 Mg ha^{-1}). Le labour minimum du sol a entraîné dans le plus faible rendement (4,0 Mg ha^{-1}) de la sous région humide. Dans la région semi-aride, la variabilité du climat caractérisée par des épisodes météorologiques secs a eu lieu pendant la saison de culture de LR11 conduisant à un échec total de culture. Pendant SR11/12, le paillage et le billonnage cloisonné étaient moyennement les meilleurs avec des rendements de 1,3 Mg ha^{-1} et 1.1Mg ha^{-1}.La culture intercalaire mbili et les traitements conventionnels avaient des rendements de 0,1 Mg ha^{-1} et 0,7 Mg ha^{-1}, respectivement. Dans la sous-région humide, le paillage, le labour minimum et la culture intercalaire mbili ont réduit la perte de sédiments du sol de 47%, 33% et 4% respectivement par rapport au témoin. Dans la région semi-aride, le paillage, le billonnage cloisonné et la culture intercalaire mbili ont réduit la perte de sédiments du sol de 65%, 48% et 39% respectivement par rapport au témoin. Le ruissellement n'a pas été influencé de façon significative par les traitements dans les deux sites expérimentaux et a été généralement dans l'ordre décroissant de labour minimum, de traitement de contrôle, de la culture intercalaire mbili et du paillage dans la région sous-humide et du traitement de contrôle, de la culture intercalaire mbili, du paillage et du billonnage cloisonné dans la région semi-

aride. Les nutriments du sol se sont améliorés remarquablement avec les stratégies de conservation.

Mots clés: Hauts plateaux du centre du Kenya, efficacité d'utilisation de l'eau de pluie, technologies de conservation des sols et de l'eau, *Zea mays* L.

Background

Farmers in the Central highlands of Kenya have experienced declining crop yields in the recent decades (Mugwe *et al*., 2009). Soil fertility related factors such as unsustainable soil management practices characterised by continuous cropping without addition of adequate fertilisers and manures, nutrient loss through crop harvest and soil erosion have been identified as principal causes of declining crop yields (Mucheru-Muna *et al*., 2007). The problem is further compounded by low, erratic and unreliable rainfall attributed to climate variability. In order to increase maize yield and reduce crop production risks arising from soil fertility loss, soil erosion and climate related stressess, a focus on rainwater management that target maximisation of rainfall infiltration into the soil and its retention in the root zone is paramount. Appropriate soil and water conservation strategies can lead to soil nutrient restoration, best use of rainwater, buffering against climate related stresses and increasing farmers yield levels.

The study was done to establish the potential of soil and water conservation strategies in coping with weather and climate variability under rain-fed maize (*Zea mays* L.) production systems.

Literature Summary

Rain-fed agriculture will remain the dominant source of staple food production and the livelihood foundation of the majority of the rural poor in sub-Saharan Africa (SSA) (Cooper *et al*., 2008). Farmers from various districts in Kenya have indicated that, soil fertility decline has been a major concern over the last five decades (Nandwa and Bekunda, 1998). Soil erosion, nutrient depletion and other forms of land degradation reduce water productivity (Bossio *et al*., 2010), nutrient use efficiency and agricultural productivity. The ability of agricultural communities and agricultural stakeholders in SSA to cope better with the constraints and opportunities of current climate variability must be enhanced for them to be able to adapt to future predicted climate change (Cooper *et al*., 2008). The central highlands of Kenya region has in the recent past experienced erratic rainfall distribution and unpredictable weather patterns that can be

linked to climate variability. Previous studies have reported improved maize and other crop yield with tied ridging, mulching, minimum tillage and maize legume intercrop in years with dry to near normal rainfall even without any nutrient inputs, and reduced seasonal average runoff in comparison to control treatments without soil and water conservation strategies (Jensen *et al*., 2003; Bationo *et al*., 2007; McHugh *et al*., 2007; Chakraborty *et al*., 2008; Giller *et al*., 2009).

Study Description

The study was conducted at Kigogo station (sub-humid region) in Meru South District, Tharaka-Nithi County and Machanga' station (semi-arid region) in Mbeere South District, Embu County. The two sites in the Central highlands of Kenya have contrasting soil fertility and highly variable rainfall patterns. The study was carried out for two consecutive cropping seasons, Long rains (LR) 2011 and Short rains (SR) 2011/2012. Four soil fertility amendment technologies; mulching, intercropping, tied ridging and minimum tillage were evaluated against conventional tillage (control treatment). A randomised complete block design (RCBD) with three replicates was adopted. The experiments were implemented in runoff plots measuring 3 x 12 m ($36m^{2)}$ fitted with collection equipment (runoff tanks) at one end. The other three sides were bound with corrugated iron sheets measuring 2 metres high and buried into the ground to a depth of one metre. Maize (*Zea mays* L.), was the test crop. The plots were sampled at the beginning and end of the experiment at 0–15 cm depth and the soil analysed for pH, Ca, Mg, K, C, N, P and texture. Soil moisture was determined in the field using Diviner 2000 device at a fortnight interval from planting to late stages. Rainfall and temperature were recorded through automatic rain gauge (0.2mm per tip) with a data logger installed about 1 km from the experimental plots. Runoff water was sampled after every rainfall event and sediments extracted at oven dry basis for analysis of soil chemical parameters. All soil analyses followed the standard methods (Ryan *et al*., 2001). Where necessary, modifications were applied appropriately. Maize grain and stover were harvested at maturity from a net area of $21m^2$ and $18m^2$ at Kigogo and Machanga, respectively. Grain and cobs were air dried to 12.5% moisture content. Yield data, soil properties, sediment and runoff data and soil moisture content obtained were subjected to analysis of variance (ANOVA) using SAS 9.1.3. Correlation was done to establish the relationship between rainfall intensities and nutrient loss. Significantly different means were separated using Fisher's protected least significance difference test (L.S.D.) at $P = 0.05$.

Research Application

All the treatments at Kigogo resulted in an increase in soil pH, exchangeable calcium, exchangeable magnesium, exchangeable potassium, organic carbon and total phosphorus after the one year experimental period. Total nitrogen increased in all treatments with an exception of the control. At Machanga, soil pH declined in all treatments. Highly variable increases were recorded in exchangeable calcium, exchangeable magnesium, exchangeable potassium, organic carbon, total nitrogen and total phosphorus across the different treatments. Mbili intercrop, mulching and minimum tillage improved maize grain yield by 32%, 14% and 7% respectively over the control treatment at Kigogo during the season of poor harvest but suppressed yield by 6%, 8% and 20% respectively during good harvest. At Machanga, meteorological dry spell experienced at the critical crop development stage; flowering, led to total crop failure in the season LR 2011. During the cropping season SR 2011/ 2012, mulching and tied ridging increased maize grain yield over the control by 87% and 60%. Mbili intercrop on the other hand suppressed maize grain yield by 84%. Significant variations in soil moisture were observed among different treatments throughout the experimental period. This had an influence on the grain yields obtained. Runoff and sediment yield also varied significantly among different treatments.

Table 1. Maize yields (Mg/ha) under different technologies during LR 2011 and SR 2011/2012 at Kigogo and Machanga.

Treatment	2011 Long rains	2011 Short rains	2011 Long rains	2011 Short rains
	Kigogo		Machanga	
Mulching	6.1	2.6	0.0	2.6
Mbili Intercrop	7.0	2.7	0.0	0.2
Minimum tillage	5.7	2.3	-	-
Tied ridging	-	-	0.0	2.2
Conventional tillage	5.3	2.9	0.0	1.4
LSD	1.3	1.0	0.0	1.2

p value =(0.05).

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