FARMER PERCEPTIONS ON SUB-SOILING/RIPPING TECHNOLOGY FOR RAIN-WATER HARVESTING IN MIXED DRY LAND FARMING AREAS IN EASTERN KENYA

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Abstract

Sub-soiling/ripping technology for rainwater harvesting was demonstrated to farmers in agro-ecological zones (AEZs) 4 and 5 in Mwala, Yatta and Kitui districts in eastern Kenya from 2007-2009. Participating farmers were involved in evaluating the benefits of enhancing soil moisture through use of this technology. The results showed that sub-soiling/ripping for rain water capture increased maize mean total dry matter (TDM) by 29-117% compared with conventional tillage. Mean maize grain yields (kg/ha) was increased by 84% in Yatta AEZ 5 and by 38% in Mwala AEZ 4. Yield increases were more for Katumani Composite B (KCB) maize planted in AEZ 5 than that planted in AEZ 4. The benefits of rain water harvesting through sub-soiling and ripping were increased when combined with application of 20 kg N plus 20 kg P_2O_5 /ha at planting in AEZ 5 and 5t/ha FYM and topdressing with 20 kg N/ha for KCB maize in AEZ 4. Sub-soiling/ripping significantly ($p \leq 0.05$) enhanced soil moisture retention in the 10-30 cm soil depth. Farmers expressed their willingness to adopt the technology, but indicated the need for the technology to be /modified for enhanced adoption. In terms of yield increase, the effect of this technology is greater in AEZ 5 than in AEZ 4.

Key words: soil sub-soiling/ripping, rain water harvesting, maize yields, agro-ecological zones

Introduction

Inadequate soil moisture is the most limiting constraint to land productivity in the semi-arid lands of Kenya (Itabari *et al.,* 2004). Research conducted in this region over the years has pointed out that rainwater harvesting in combination with improved soil fertility has potential to significantly increase crop production (Itabari and Wamuongo*,* 2003, Gichangi *et.al*. 2007). The rainwater harvesting technologies that have been tested and found suitable for increasing crop productivity are those that retain rainwater in situ in the farms for crops like the tied and open ridges or that allow rainwater to be retained on open furrows for longer duration as the water infiltrates the soil or soil management techniques that favour prolonged rainwater infiltration and retention, thus raising the overall soil moisture retention and soil water holding capacity (Itabari *et al.* 2003). However, a majority of the soils found in this region have developed hardpans at around 4 inches of soil depth, which slows rainwater infiltration, leading to rain water loss through runoff, which in turn carries away top fertile soil required for healthy crop growth. The soils are susceptible to hardpan formation due to their inherent low organic matter, which leads to weak soil aggregate stability. Soil aggregates are broken down to fine aggregates, which join and form a seal of impermeable layer with time. The soils become susceptible to erosion (Kilewe, 1987), loss of rainwater due to decreased infiltration as the bulk density of the few inches of the top soil increases, thereby limiting infiltration. This has been observed in semi-arid Makueni district (Miriti *et al.*, 2009) where the top 0-15 cm soil was found to have higher bulk density than the soils below this depth. A special soil management technique is required for soils in the semi-arid lands because of these inherent properties.

The rainwater harvesting technologies that have been extensively tested and found suitable for increasing soil moisture for increased land productivity are mainly the tied and open ridges, zai pits, half moons, rock bunds (Itabari *et al*., 2004) and sub-soiling/ripping (Miriti *et al*., 2009; Steiner and Rockstrom, 2003; Mwangi *et al.,* 2005). These technologies allow rainwater retention for a prolonged duration on the soil surface for increased infiltration and soil water retention and better rainwater use efficiency in the semi-arid lands (Steiner and Rockstrom, 2003).

Sub-soiling/ripping has been found to increase crop production by 40-60% in the semi-arid lands (Steiner and Rockstrom, 2003; Mwangi *et al.*, 2005). These lands lose 60-75% of rain water through surface runoff due to land topographic features and inherent soil properties (Kilewe, 1987).

Despite the reported benefits of sub-soiling/ripping rainwater harvesting technology in the region, there is very limited information on farmers using this technology in the region.

The Kenya Arid and Semi-Arid Lands Research Programme (KASAL) has been up-scaling and promoting integrated soil fertility and suitable water harvesting technologies in the region since 2007 in agro-ecological zones 4 and 5. The project has been demonstrating the use of tied /open ridging and sub-soiling/ripping for the last four seasons in Mwala district (AEZ 4) and in Yatta and Kitui districts (AEZ 5). This paper highlights the perceptions of farmers on the appropriateness of sub-soiling/ripping technology in the region.

Materials and Methods

Up-scaling and promotion of integrated soil fertility and suitable strategies for rainwater harvesting for increasing productivity in mixed dry land farming in the semi-arid areas of Mwala, Yatta and Kitui districts started in the short rains (SR) of 2007/08. The project was conducted through demonstrations and training on rainwater harvesting technologies and soil fertility replenishment through use of recommended rates of manures and fertilizers. The demonstrations were conducted in SR of 2007, 2008 and 2009 and in the long rains (LR) of 2008, 2009 and 2010. In Mwala district, the project was implemented in four cluster sites: Ngenda, Kombe, Kwalumbu and Kyawango all in AEZ 4. In Yatta district, the project was carried out at Kyasioni (AEZ 5) and in Kitui AEZ 5, the project was carried out in Kauwi location (AEZ 5). At all demonstration sites, local community based organizations (CBOs) were involved. Demonstrations/trainings on rainwater harvesting technologies were conducted participatory. The demonstrations were implemented through farmer field schools (FFSs) where farmers are led to discover constraints and opportunities in a mixed dry land farming system.

Technologies for rainwater harvesting that were tested were open and tied ridges for rainwater harvesting on lands with slopes >2%. Sub-soiling and ripping was conducted on slopes of even less than 1%. The collaborating farmers participated in fixing/attaching the sub-soiler to the victory plough frame, replacing it with the ripper for widening the furrows made by the sub-soiler, planting and covering the seed. They also, together with the researchers, made observations on crop establishment, crop growth vigor and subsequent grain and/or stover yields when the seasons received below normal, normal or above-normal rainfall amounts in comparison with the long term average mean for the respective season. Farmers were also involved in evaluating performance of sub-soiling/ripping as a means of rainwater harvesting in comparison with conventional tillage using the mould board plough. The demonstration plots were 10 m by 15 m and Katumani KCB maize was used as the test crop.

Results and Discussion

The results showed that, in very dry seasons (SR 2007 and LR2009) sub-soiling/ripping increased TDM of maize by 29-117%. The increase in TDM was more in Kitui (AEZ 5) where soil moisture was very limiting (Table 1). This was also observed at Kyasioni in Yatta district (AEZ 5) during a season of above normal rainfall (SR 2009) (Table 3). Sub-soiling /ripping increased KCB maize grain yields by 84% compared to yield increase of 38% at Kyawango, Mwala district (AEZ 4). This implies that sub-soiling/ripping is a superior technology for rainwater harvesting in AEZ 5. KCB maize responded more to fertilizer and fertilizer plus manure application in AEZ 5 than in AEZ 4 in seasons of high rainfall amounts. This could be attributed to the slope of the demonstration site at Kyawango. At this site, there was considerable runoff due to slope of the land which was about 5%. Kyasioni site had a slope of less than 2%. In general, sub-soiling/ripping increased KCB maize grain yield and TDM more in AEZ-5 than in AEZ 4. Fertilizer application at 20 kg N plus 20 kg P_2O_5 /ha increased yield more in AEZ 5 than in AEZ 4 when combined with sub-soiling/.ripping. These results corroborates the findings obtained in semi-arid (AEZ-UM4) area of Kalama location, Machakos district where sub-soiling/ripping increased mean maize grain yields by 50% and mean total biomass by 86% (Mwangi *et al*., 2005) and the observations of Miriti (2009) who reported that sub-soiling/ripping increased mean TDM of maize by 34% in comparison to conventional oxen ploughing in AEZ 5 in semi-arid Makueni district.

Farmers' evaluation of soil sub-soiling/ripping technology for rain water harvesting across the sites (Table 4) showed that, sub-soiling/ripping is effective method for rain water harvesting in AEZ 4 and 5. The impact of rain water harvesting is enhanced by application of 20kg P_2O_5 + 20kg N /ha or 5t FYM +10kg.

Table 1: Farmers' observations on maize Total Dry Matter (TDM) yield (kg/ha) in Mwala (AEZ-4) and Kitui (AEZ-5) from sub-soiled/ripped and conventionally tilled farms in SR2007 and in Mwala LR 2009.

			Total dry matter yield (kg/ha) Treatments		% yield increase
Farmers name	**District**	**season**	**Sub-soiling/ripping**	**Conventional tillage**	
A Muli	Mwala	SR 2007	239	102	134
Tabitha	Kitui	SR 2007	50	25	100
Kalumu	Kitui	SR 2007	350	167	109
Mean			**213**	**98**	**117**
Alize Musyoka	Mwala	LR 2009	189.8	222.2	
B Muoki	Mwala	LR 2009	766	570.0	34

M Kiingu	Mwala	LR 2009	283	438	
A Muli	Mwala	LR 2009	590	189	212
Mean			**457.2**	**355**	**29**
Lsd (5% level)			392.3	392.3	
CV %			47.4	47.4	
s.e.d			123.3	123.3	
% mean yield increase by subsoiling/ripping			29%		
Significant test ($P \leq 0.05$)			*none*	*none*	

Table 2: Trend of mean soil moisture content with depth in sub-soiled soils in farmers farms in Mwala (LR 2009)

Depth	Soil moisture content kg/kg soil
0-10cm	0.0342
10-20cm	0.0616**
20-30cm	0.0738***
LSD ($P \leq 0.05$)	0.01004

Means followed by asterisks are significantly different.

Table 3: Farmers perception on effect of integrated soil fertility and tillage methods on maize grain yields (kg/ha) in Mwala AEZ- 4 and Yatta AEZ- 5 (SR 2009).

Site	Treatments			
Kyasioni (AEZ-5) Yatta	Soil fertility Management	Sub-soiling/ripping	Conventional tillage	%Yield change
	5t/ha FYM	1530	1630	-6%
	5t/ha FYM +20kg N/ha	1710	1080	58%
	(20kgN +20kg P_2O_5)/ha	3710	933	298%
	5t/ha FYM + (10kg +10kg P_2O_5)/ha	2210	1340	65%
	Mean	**2290**	**1246**	**84%**
Kyawango (AEZ-4) Mwala	5t/ha FYM	2430	1680	45%
	5t/ha FYM +20kg N/ha	2950	1810	63%
	(20kgN +20kg P_2O_5)/ha	2220	2020	10%
	5t/ha FYM + (10kg +10kg P_2O_5)/ha	3370	2450	38%
	Mean	**2743**	**1990**	**38%**

P_2O_5 +10kg N /ha in AEZ 4 and 5 on grey sandy clay soils. In red loamy soils, soil sub-soiling/ripping with application of FYM at 5t/ha had the best maize growth vigor and bigger many cobs as observed by farmers (Table 4). This confirmed that, water use efficiency of rain water in semi arid lands is enhanced by use of soil fertility improvement technologies (Miriti *et al*., 2009).

Table 4: Farmers perception on soil sub-soiling/ripping technology for rain water harvesting in Mwala (AEZ-4) and Yatta (AEZ-5) and soil fertility improvements for Katumani (KCB) maize (LR 2010)

AEZ	Land preparation /best input rate	proportion farmers scoring for	proportion farmers scoring against
AEZ-5, Yatta (Pastor farm)	Sub-soiling/ripping	20/44	24/44
	Mould board	28/44	16/24
	5t FYM	2/44	
	5t FYM + 20 kg N	3/44	
	20kg P_2O_5 +20 kg N	18/44	26/44
	5t FYM + 10kg P_2O_5 +10kg N	44/44	0
Yatta (AEZ. 5) Myatu farm	Sub-soiling/ripping	20/28	8/28
	Mould board	8/28	20/28
	5t FYM	21/28	
	5t FYM + 20 kg N	9/28	

	$20kg\ P_2O_5$ +20 kg N	0	
	5t FYM + $10kg\ P_2O_5$ +10kg N	0	
Mwala (AEZ 4)	Sub-soiling/ripping	56/67	11/67
Mbiuni	Mould board	11/67	56/67
	5t FYM	1/67	
	5t FYM +2Okg N	7/67	
	$20kg\ P_2O_5$ +20 kg N	58/67	7/67
	5t FYM + $10kg\ P_2O_5$ +10kg N	50/67	6/67

Soil sampling for moisture content analysis over the growing season in LR 2009 showed soil moisture to be significantly ($P \leq 0.05$) concentrated in 10-30 cm soil depth (Table 2). This implied that when rains are far below long term average, the available soil water can support deep rooted crops like pigeon peas in AEZ 4 and not maize. Similar observations have been reported in AEZ 5 (Miriti *et al*., 2009) while investigating the effects of conservation tillage on water use efficiency in maize-cowpea cropping system in semi-arid eastern Kenya, where, sub-soiling/ripping had the highest water storage in the soil in the dry season (LR2007). Elsewhere in semi-arid and dry sub-humid areas of Tanzania, rainwater productivity was increased from 1.5 kg /mm/ha to 2-4 kg/mm/ha with introduction of sub-soiling/ripping (Steiner and Rockstrom, 2003).

Farmers' evaluated the effect of sub-soiling/ripping on KCB maize growth and yield and within the two study sites (Fig.1), concluded that sub-soiling/ripping increases crop production, but noted that the technology had shortcomings; in some places, the soil is so hard that a double pass is necessary to open the soil to the required depth and replacing the sub-soiler with the ripper is time-consuming. This has been reported to be a drawback of this technology (Steiner and Rockstrom, 2003).The farmers felt that modifying this technology so that both sub-soiling and ripping are done in one pass would make it more attractive. Farmers further observed that, the technology is not suitable for soils in stony areas, when there is more rainfall and the technology is suitable for red soils particularly in AEZ 5. Soil sub-soiling is similar to soil deep tillage which has been reported to increase sorghum yield by 3 times over conventional tillage (Itabari, 1999). Further farmers' evaluation of soil sub-soiling/ripping technology for rain water harvesting across the sites (Table 4) showed that, sub-soiling/ripping is effective method for rain water harvesting in AEZ 4 and 5. The impact of rain water harvesting is enhanced by application of 20 kg P_2O_5 + 20 kg N /ha or 5t FYM +10 kg P_2O_5 +10 kg N /ha in AEZ 4 and 5 on grey sandy clay soils. In red loamy soils, soil sub-soiling/ripping with application of FYM at 5t/ha had the best maize growth vigor and bigger many cobs followed by application of 5t FYM/ha at planting and topdressing with 20 kg N/ha as observed by farmers (Table 4). This confirmed that, water use efficiency of rain water in semi arid lands is enhanced by use of soil fertility improvement technologies (Miriti *et al*., 2009). Illustration on farmers evaluation of soil sub-soiling/ripping technology for rain water harvesting and tools used and observed yields is shown in plate 1 to 5.

Conclusions

Farmers concluded that sub-soiling/ripping increases crop yields, but indicated a need for a simplified way of achieving the same objective. This technology is more beneficial for maize production in AEZ 5 when combined with 20 kg N plus 20 kg P_2O_5 /ha or 5 t/ha FYM when planting and top- dressing with 20 kg N/ha in AEZ 4 when the crop height is 45 cm. . Sub-soiling/ripping is an effective and profitable method of rainwater harvesting as it increases rainwater use efficiency, which reduces risk of yield losses due to drought, thereby increasing food security. Sub-soiling/ripping increases rainwater infiltration, retention, extensive crop root nutrient and water exploration area and depth, and increases soil moisture and water storage capacity. The impact of rain water harvesting is enhanced by application of 20 kg P_2O_5 + 20 kg N /ha or 5t FYM +10 kg P_2O_5 +10 kg N /ha in AEZ 4 and 5 on grey sandy clay soils. In red loamy soils, soil sub-soiling/ripping with application of FYM at 5t/ha had the best maize growth vigor and bigger many cobs followed by application of 5t FYM/ha at planting and topdressing with 20 kg N/ha.

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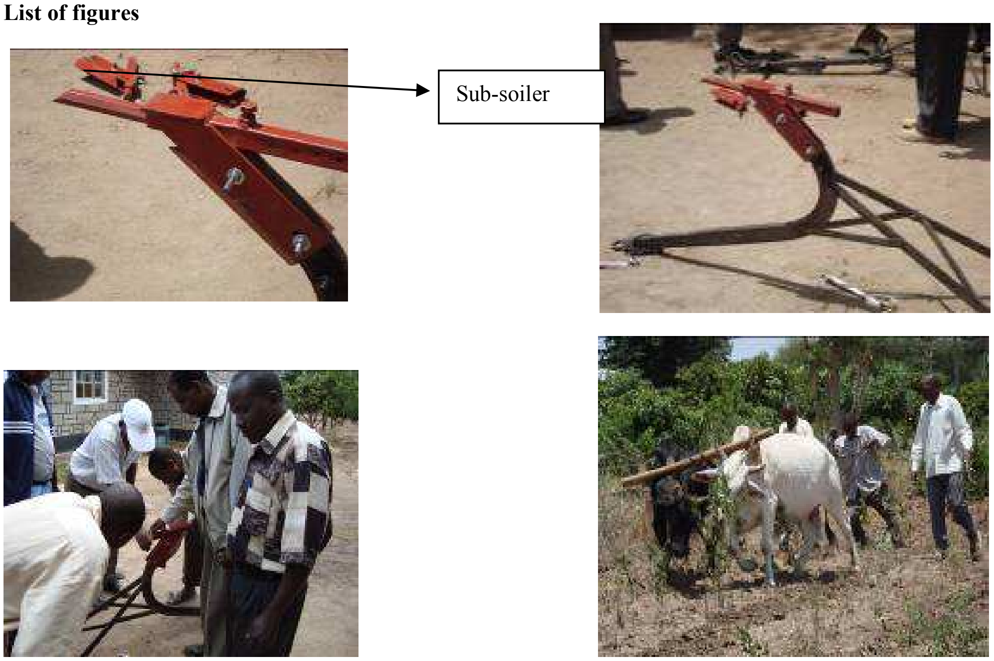

Fig 1*. soil sub-soiler being fitted on victory plough to do sub-soiling using animal power and farmers being demonstrated exchange of sub-soiler with ripper for widening planting furrows during land preparation in Mwala SR2008.*

__Fig 2.__ Ripper fitted in exchange for sub-soiler and wide furrows made after widening the 6inch deep narrow furrow left by sub-soiling.

__Fig 3.__ A female farmer has hands on soil sub-soiling during land preparation in Mwala SR 2008

Fig 4. *Farmers, agricultural officers from Mwala district and scientists discuss benefits of soil sub-soiling/ripping in Mwala SR 2008*

Fig 5. *Farmers compare maize cobs harvested from plots sub-soiled/ripping and those from plots under conventional tillage in Yatta SR2009.*