ABSTRACT

Crop cultivation suffers with poor yield and land productivity due to soil moisture stress and insufficient rain during dry season particularly in eastern parts of Rwanda. Rainwater interception, soil moisture conservation and supplemental irrigation using ground water can be integrated to combat crop water stress thereby increase land productivity. The study explores the best technical option to resolve the constraints related to water management in maize cultivation on hill land. Focussing potential of improved maize production combating dry season, efficiency of in-situ soil moisture conservation techniques and supplemental irrigation system were compared to complement and sustain rain-fed agriculture.

First preliminary study on in-situ soil moisture conservation techniques in bench terraces and unterraced field with maize crop had been conducted from June 2007 to October 2007. Bench terrace increased the average soil moisture content in 90 cm soil depth by more than 50percent than that of unterraced land. Within the bench terraced field compartment bund and ridges & furrows increased soil moisture by 19.5 and 27.9percent higher than plain bed. In terms of efficiency of moisture conservation, ridges & furrows performed well with 85.8percent followed by compartment bund with 75.9percent in terraced field. Unterraced field conserved moisture very meagre with 13.9percent efficiency inferring importance of bench terraces for soil moisture conservation. No maize grain yield was recorded in all the techniques because soil water depleted to 60percent and above from the beginning of the cropping period inferring the need of supplementary irrigation. Analysis of rainfall, crop water demand and in-situ moisture conservation reveals exciting opportunities for water productivity enhancements by integrating components of
water management within the context of rainfed farming through water harvesting and supplemental or micro irrigation for dry spell mitigation.

A second preliminary study on Effect of different insitu water conservation techniques on maize production under supplemental irrigation in terraced land during late long rainy season was conducted from May to August 2008. The study is based on moisture content analysis performed by monitoring soil moisture measurement. Four techniques of moisture conservations with mulch were selected for the experiment and soil moisture data were analyzed in different periods during crop cultivation. The study shows that maize straw mulch performed well more or less in all structures particularly in ridges and furrows with maximum mean soil moisture of 12.5 percent and is followed by grass mulch with maximum mean soil moisture of 11.6 percent. This is due to the thickness of maize straw mulch and resistance to air flow on soil surface provided by ridges. Grass mulching was done with fresh grasses which was not dry like maize straw and reduced weight after drying. So, quantity of grass straw has been increased if it is wet so that it will be comparable to dry maize straw.

The mean soil moisture content among the four types of water conservation techniques did not vary significantly at 15cm soil depth. The soil moisture content at 40cm depth is higher than that of 15cm but still the difference is very marginal due to the coarse lateritic soil and low organic matter content. Among the moisture conservation techniques, the analysis shows that compartment bunds and ridges and furrows with maize straw mulch can conserve more moisture than flat beds. It is also found that rainfall plays a crucial role to influence the performance of insitu moisture conservation techniques. With no supplementary irrigation after flowering yielded
only straw while supplemental irrigation yielded 1.8 and 1.5 tons per hectare under supplemental irrigation.

Based on the preliminary study results obtained in second seasons of 2007 and 2008, suitable land configuration, mulching and different irrigation regimes with drip irrigation was formulated as first main experiment and test verified during first seasons of 2008 and 2009. As a second main experiment drip irrigation with lateral spaced at 60 and 120 cm basin irrigation were compared under different irrigation regimes and organic manure doses.

First experiment revealed that maize straw mulch combined with Broad Bed and furrow (BBF) land configuration on bench terrace yielded 4.15 tons per ha of grain when supplied with 182mm of supplemental irrigation by drip irrigation with one lateral for two plant rows. Maize straw mulch performed well in both BBF and CB with irrigation water use efficiency of 10.15 and 10.38Kg irf$^3$ respectively when irrigated with 27 mm net supplemental irrigation.

Irrigation method, irrigation regime and organic manure application have significant effect on dry grain yield and biomass yield but interaction effect of organic manure with irrigation method was not significant. Basin irrigation followed by drip irrigation performed well in terms of grain yield but in terms of water use efficiency, drip irrigation with one lateral for two plant rows performed better compared to other irrigation methods under organic manure dose of 15tons ha$^{-1}$.

Highest average irrigation water use efficiency of 17.5 kg nr$^3$ was obtained in drip laterals spaced at 120cm and 75 percent irrigation water can be saved for 33.6 percent yield reduction compared to check basin irrigation. In year 2009, drip irrigation with 120cm lateral spacing saved 53 per cent water for 31 per cent yield reduction when applied with 43 percent of actual water demand under organic manure application of 15tons ha$^{-1}$. Under water scarce conditions, it is recommended to use
drip irrigation with laterals spaced all 20cm and apply irrigation from flowering stage of crop under organic manure dose of 15tons ha to achieve maximum water use efficiency by practicing deficit irrigation.

Maximum production of 5.4 tons ha and 4.8 tons ha respectively were obtained in basin and drip irrigation. Laying one drip lateral for two rows of maize will be economical and results maximum irrigation water use efficiency with a production of 3.5 tons ha of dry grain yield. Supplemental irrigation is inevitable to ensure maximum crop yield from hill land Agriculture in Eastern part of Rwanda. There is tremendous potential for improving production in rain fed agriculture through supplemental irrigation by micro irrigation systems using conjunctive use of ground water and runoff water harvesting.