ANALYSIS OF SOIL MOISTURE CONSERVATION TECHNIQUES WITH DRY SEASON MAIZE CROP ON HILL LAND AT RUBIRIZI, RWANDA

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ABSTRACT

Rwanda is an agriculture based country where crop production is carried out under rain fed situation with wide range of agro climatic conditions. Field experiments were conducted with in-situ soil moisture conservation techniques in bench terraces and unterraced field by using maize crop variety Kathumani from June 2007 to October 2007 by involving three land management practices viz. ridges and furrows, compartmental bunding and control. The study explores the best technical option to resolve the constraints related to water management in rainfed farming in Rwanda. Insufficient rainfall during dry season attracts the need of water harvesting and soil moisture conservation. The study is based on weekly soil moisture analysis in 90cm soil depth. Analysis of rainfall and crop water demand indicates that it is inevitable to provide supplemental irrigation and in-situ moisture conservation for successful crop. Bench terrace increased the average soil moisture content in 90cm soil depth by more than 50 per cent than that of unterraced land. Within the bench terraced field compartmental bunding increased soil moisture by 18.2 per cent higher than plain bed (control) with a coefficient of variation of 20.6 per cent and ridges & furrows increased by 27.8 per cent with coefficient of variation of 29.3 per cent. This indicates that in-situ moisture conservation measures are effective to increase soil moisture compared to plain bed. It is also found that mean soil moisture fluctuation in the soil profile is moderately more at 60cm depth compared to 30 cm irrespective of type of conservation techniques.

Performance of ridges & furrows, compartmental bunding and plain land (control) was evaluated in terms of soil moisture conservation. The study reveals that Compartmental bunding performed well in both 30cm and 60cm soil depths followed by ridges & furrows because of consistent soil moisture as evidenced by less coefficient of variation. Higher moisture content in these two techniques is due to water barrier to harvest rainwater. Average soil moisture content for compartmental bunding and ridges & furrows varied between 16 to 17 per cent at both 30cm 60 cm soil depths and 13 per cent for plain bed (control). In all the three techniques, actual soil water during the entire cropping period remains below field capacity posing soil moisture stress. The maize yield was very poor in all the techniques because the soil water depleted to 60 per cent and above from the beginning of the cropping period inferring the need for supplementary irrigation. Plain bed (control) exhibited lowest degree of fluctuation of deficit water indicating poorly influenced by rain fall as compared to ridges & furrows and compartmental bunding. In terms of efficiency of moisture conservation during the cropping period, ridges & furrows performed well with 85.8% followed by compartmental bunding with 75.9 per cent in terraced field. Unterraced field with 15 per cent slope conserved moisture very poorly with 13.9% efficiency inferring importance of bench terraces for efficient soil moisture conservation. Performance of different in-situ moisture conservation practices were analyzed in terms of available water, deficit water, crop water and its effect on maize yield was discussed in this paper

Key words : Bench terrace, In-situ moisture conservation, deficit water, crop water, available water, conservation efficiency

1.0 INTRODUCTION

Rain fed farming in Rwanda is been carried out in more than 95%. The land available for cultivation is 52 percent of the total surface area posing land scarcity for agriculture and need to improve land productivity. Presently, less than 3 % of the arable land is under irrigation and remaining is rain fed area giving low production due to poorly distributed rainfall.

In Rwanda, almost 90% of the potential soils for agricultural production are located in hillsides with very steep slopes (Delepierre and Prefol, 1973). Crop cultivation suffers with land productivity and poor yield due to insufficient rainfall during dry season especially in Eastern parts of Rwanda. Therefore supplementary irrigation and moisture conservation techniques must be adopted to fight against soil moisture deficits so that land productivity and yield can be increased. This project work focuses on performance evaluation of insitu soil moisture conservation techniques with respect to soil water storage during maize cultivation under low rain fed condition. At present, farmers are practicing widely ridges & furrows, plain field for maize cultivation on bench terraces. Compartmental bunds and vertical mulching are the other available options and the latter is not suitable for this area because of porous subsoil. Performance of these techniques to conserve soil moisture and the extent of supporting the crop under site specific environment is not well understood. This information provides basic input for selection of suitable conservation method and crop planning.

In-situ rain capture systems are normally defined as soil and water conservation (SWC) practices (Gowing *et al.*, 1999). Capturing rainwater where it falls and storing it in the root zone is perhaps the most cost-effective means of increasing water availability for plants. For example, converting from plowing to sub-soiling and ripping in parts of semi-arid Tanzania led to doubling of yields in good years (Jonsson, 1996). Harold (1986) studied water deficits imposed during vegetative and grain filling stages had similar effects on corn yields. Yield reductions from 2and 4week deficit periods during vegetative growth were 23 and 46%.Corn is more sensitive to water deficit during pollination.

Dimitrina Stoyanova1 et al. (2002) studied the structure of the 7th, 8th and 12th leaf of maize plants grown under conditions of 80%, 60% and 40% of full moisture content. Data from anatomical analysis showed that the gradual depletion of soil moisture does not provoke substantial histological changes. Analysis of the leave's ultrastucture revealed that the water deficit (at 40% of soil moisture content) caused a typical destruction of thylakoids in the mesophyll chloroplasts.

Russell (1978) concluded that an adequate agronomic description of a soil moisture profile must indicate when, where and how much water is available in the soil throughout the growing season. In Australia, *Williams et al* (1983) estimated that a profile moisture store of less than 100 mm had a less than 30% probability of meeting the moisture requirement of a sorghum crop, and even 200 mm had only a 70% probability of meeting the requirement. According to Tenge *et al* (2005) in situation where moisture is the limiting factor, crop yields are expected to be higher on bench terraces. They found that average moisture retention from sixteen (16) experimental plots varied from 34 to 36% in Tanzania.

One suggestion for identifying suitable moisture conservation method is to compare rainfall with crop requirements (Narayana and Ram Babu 1985), giving three conditions:

- Where precipitation is less than crop requirements; here the strategy includes land treatment to increase run-off onto cropped areas, fallowing for water conservation, and the use of drought- tolerant crops with suitable management practices.
- Where precipitation is equal to crop requirements; here the strategy is local conservation of precipitation, maximizing storage within the soil profile, and storage of excess run-off for subsequent use.
- Where precipitation is in excess of crop requirements; in this case the strategies are to reduce rainfall erosion, to drain surplus run-off and store it for subsequent use.

There can be wide variations of moisture shortage and surplus, both within and between seasons. A drought year whose total rain is well below the long-term average may still include periods of excessive rain and flooding, while a high rainfall season may include periods of drought. This makes the choice of method difficult, because the desired objective may change from one season to another. In this research the effects of different in-situ moisture conservation methods on soil water are evaluated using scientific principles.

2.0 JUSTIFICATION

The study has been conducted at Rubirizi Terraced area known as ISAE Rubirizi farm.The area is well known for having low rainfall especially during May to August. In Rubirizi rainfed farming is practised and rainfall is insufficient to support crop production consistently. The problem is further aggravated by fast drying of soil by hot weather and poor water holding capacity of coarse textured laterite soil. Therefore crop production is affected due to soil moisture stress especially during dry seasons. For improving soil moisture and crop productivity water conservation measures are required and it is impossible to store water without lining harvesting structures which is somehow expensive. So, suitable method of insitu soil moisture conservation has to be decided based on storage capacity of soil and its seasonal variation. If the soil is kept always to its maximum storage capacity by suitable water conservation measures during cropping period, expensive water harvesting structures may not be required. This needs to understand rain water interception, its distribution and contribution to different components of water balancing process. Also information on variation of soil moisture pattern in the soil profile will help us to plan cropping pattern.

In most areas of Rwanda land is left fallow because of failure of timely rainfall and insufficient rain during dru season. The proposed study will explore the best technical option to resolve the constraints in rainfed farming by answering the following questions.

1. How best rainfed farming can be supplemented by soil moisture conservation techniques?
2. How best maize crop utilises available soil water during different growing stage?
3. How far are the crop water needs met by rainfall?
4. What type of agriculture should be practiced in low rainfall areas?

3.0 OBJECTIVES

In order to support efficient planning of soil moisture management for sustainable agriculture, the study of effective moisture conservation techniques in bench terraces at Rubirizi had been conducted with the following objectives.

- To monitor soil moisture variation in soil profile during dry season.
- To evaluate performance of in-situ soil moisture conservation techniques practised by farmers.
- To analyse available water and water deficit during cropping period.

4.0 METHODOLOGY

4.1 Description of Area

Rubirizi is located at 15km from Kigali city in Kanombe sector of Kicukiro district. It lies at 1 degree 57,245 minute South and 30 degree 3,750 minute East in hilly terrain with altitude ranging from +1433m to +1645m. The research site is in ISAE farm which is terraced with an extent of 30Ha. Crops cultivated are maize, beans, pineapple etc. The area has four seasons namely short rainy season, long rain season, short dry season and long dry season. The Temperature varies between 14 and 28ºC. The maximum monthly mean temperature is about 24 to 28ºC whereas the minimum is about 14 to 18ºC. Mean annual rainfall is 1177mm. Rainfed farming is carried out during the rainy seasons and mostly the land is left fallow during the dry seasons.

4.2 Experimental field

The study was conducted in the bench terrace of 4m wide and unterraced hilly land at ISAE farm. Experimental plots containing three treatments of moisture conservation techniques and four replications were laid following completely randomised block design on the terrace. Plain bed, Compartment bund, and Ridges & Furrows are the in-situ soil moisture conservation practices under study. In unterraced land four replications of plain bed was made for study.

Twelve plots were made in terraced land and each plot measuring a length of 9m and width of 3.5m was spaced at 1.5m. Ridges & Furrows bed was made with 20cm furrow depth and 40cm ridge spacing. Furrow ends were closed to trap rainwater and store in the soil medium within the plot by preventing runoff. Compartment bund was made by 20cm high bunds for dividing the plot into six equal parts facilitating in-situ rainwater harvesting and maintaining soil moisture. The plain bed was made in the plot without forming any barrier to harvest rain water. Provision was made to dispose excess rain water in both compartment bund and ridges & furrows. Sowing of maize seeds was carried out with spacing of 30cm row to row and 40cm plant to plant distance. Manuring, fertilisation and other cultivation operations were performed following common practice.

4.3. Soil moisture balance

Initial and final soil moisture content for each period was recorded in all experimental plots at 30cm and 60cm soil depths for 12 different intervals during the cropping period. Rainfall and crop water demand during respective periods were arrived from meteorological data. Average soil moisture content measured 24 hours after rainfall was taken as field capacity of the soil. Any amount of soil moisture in excess of this capacity was a surplus and would be a deep percolation loss or run-off. Wilting point was taken from standard value recommended by FAO considering the soil texture class. Available soil water and depletion from field capacity are analysed for each type of moisture conservation technique. Rainfall and pan evaporation data were taken from Meteorological station of Kanombe. No supplemental irrigation was applied during the study. Format followed for soil moisture balancing is given in Table 1.

Table 1 Soil moisture balancing

Period	Initial soil moisture (cm)	Total rainfall (cm)	Crop water demand, cm	Final soil moisture (cm)	Field capacity (cm)	Available surplus/deficit water (cm)

4.3.1 Soil Moisture content determination

Gravimetric method was used for determining the soil moisture content. Moisture content at 30cm and 60cm depths were noted whenever there was an appreciable change of moisture content. Available moisture in the effective root zone depth of 90cm for maize was found out by adding the moisture content at first 30cm and the next 60cm depths. Moisture content on dry weight basis was converted into depth of water using the following formula.

$$dw = \frac{PxGaxd}{100}$$

Where, P = Moisture content percentage on dry weight basis

Ga = Apparent specific gravity of the soil

D = Depth of the roots zone, cm

dw = Depth of water, cm

Soil sample was taken by the auger and weighed immediately after sampling. Then it was dried in the hot air oven at 105°C for 24 hours. Weighed the oven dried soil and found difference in weight which is the water weight in the soil. Soil moisture content on dry weight basis was calculated by the following formula:

$$W = \frac{W_w}{W_s} \text{ x } 100$$

Where, W = moisture content in %

W_w = weight of water in soil mass in gms

W_s = weight of dry soil in gms

4.3.2 Crop water demand (ETc)

The data of weekly pan evaporation was obtained from Kanombe meteorological observatory to calculate crop water demand was used, together with suitable crop factor with respect to its variation according to the growing stage of maize. Actual evapotranspiration is calculated using the following formula.

ETc = Kp x Kc x Epan

Where, ETc = Crop water demand in mm

Kc = Crop factor (selected depending on growth stage of maize)

Epan = Pan evaporation in mm

Kp = Pan coefficient (0.8)

4.3.3. Efficiency of moisture conservation

Performance of moisture conservation technique is quantified by its efficiency. It is calculated using the following formula.

$$E = \frac{M_2 x 100}{(M_1 + R) or S_c whichever - is - less}$$

Where, E - efficiency of moisture conservation

M1 – moisture content at the beginning of cropping period

M2 – moisture content at the end of cropping period

R - Rainfall received during cropping period

S_c - Storage capacity of soil

4.4 Statistical analysis

Coefficient of variation and analysis of variation are the two statistical tools applied in data analysis and interpretation to support conclusion.

4.4.1 Coefficient of variation

Coefficient of variation is a relative measure of dispersion between two or more than two sets of data. In the present study, it has been applied to measure the variability of soil moisture %, deficit % and available water under different in-situ moisture conservation techniques during the cropping period. It is calculated using the following formula.

Coefficient of variation = (Standard deviation / Mean) x100

4.4.2 Analysis of variance

Analysis of variance enables us to test for the significance of difference between more than two samples means. In the present study, the analysis of variance has been done for the results obtained on the soil moisture in different moisture conservation techniques. In this analysis two factor analysis had been performed using Agres, statistical software.

5.0 RESULTS

Monitoring of soil moisture was conducted in the experimental fields starting from 29th June 2007 to 01st October, 2007 in the experimental plots. Soil properties, soil moisture, rainfall and evapotranspiration were recorded for analysis of soil moisture balance. The results of the analysis are presented and discussed below.

5.1 Soil properties

Soil texture, bulk density and organic carbon content are the three soil properties measured in the experimental field at 30 and 60cm depths. Soil texture analysis had been carried out in ISAE laboratory by using sieve analysis and hydrometer method. According to USDA (United States Department of Agriculture) triangle method, sandy clay loam is the soil textural class for both 30 and 60cm soil depth. It is found that the average bulk density is 1.2g/cc. Average carbon content is measured as 0.67%. This shows that carbon content in the area is very low and leads to poor soil water retention.

5.2 Crop water scarcity

Total rainfall received during each period is presented in Fig 1 with crop water demand of maize crop. It shows rainfall distribution with actual crop water requirement during the cropping period. Fluctuation of rainfall was uniform and moderate from June to September and maximum in October. Compared to crop water requirement rainfall is less during these periods inferring possibility of soil moisture deficit. Mean soil moisture fluctuation follows the rainfall pattern and rainfall in October gives extra influence on soil moisture, but still it was below field capacity. All of the periods, mean soil moisture was below field capacity, but during the last two periods soil moisture was approaching the field capacity. Total rainfall received during cropping period was 235mm and the total crop water demand was 461mm resulting water scarcity of 226mm. In general, it is inevitable to provide supplemental irrigation and in-situ moisture conservation for successful crop.

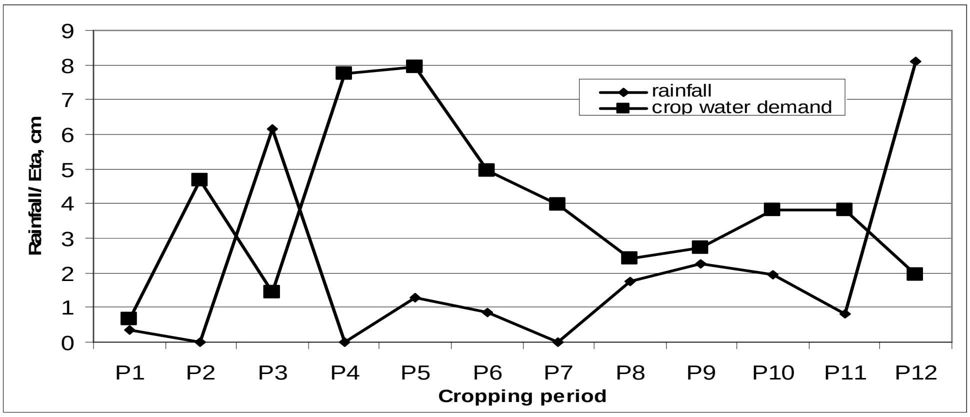

Fig 1 Rainfall and crop water demand

5.3 Mean Soil Moisture

The moisture content measurements had been done in the laboratory by gravimetric method. Mean soil moisture variations at 30cm and 60cm soil depth, obtained by variance analysis of the observed data using AGRES are presented below.

5.3.1 Effect of conservation techniques on soil moisture

Soil moisture fluctuation in the effective root zone depth of 90cm depth for unterraced field and terraced field with ridges & furrows, compartment bund and plain bed during the cropping period is presented in Fig 2. Average soil moisture of 6.8cm was observed in unterraced field whereas 15.4cm was observed in the plain bed of terraced field. This shows that bench terrace increased the average soil moisture content by more than 50% than that of unterraced land. Within the bench terraced field compartment bund increased soil moisture by 18.2% higher the plain bed with a coefficient of variation of 20.6% and ridges & furrows increased by 27.8% with coefficient of variation of 29.3%. This indicates that in-situ moisture conservation measures are effective to increase soil moisture compared to plain bed.

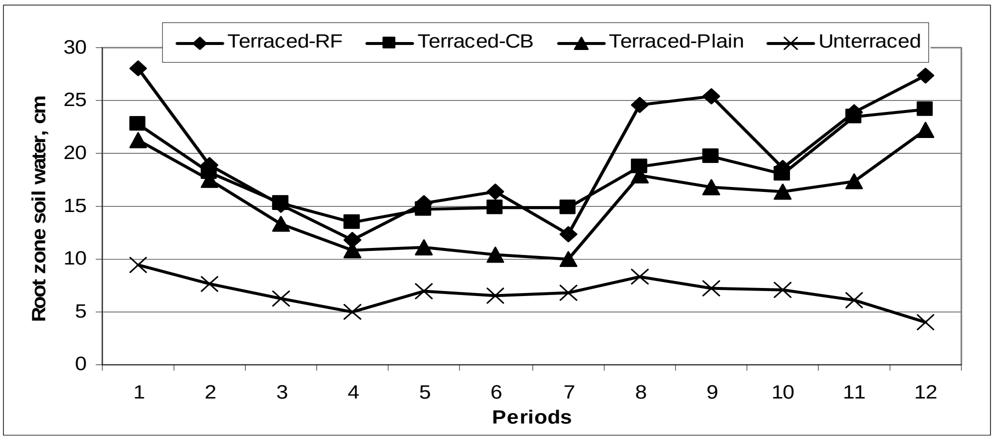

Fig 2 Effect of conservation techniques on root zone soil moisture

5.3.2 Periodic variation of soil moisture in soil profile

Variation of mean soil moisture % at 30cm and 60cm depths in all experimental plots during cropping period irrespective of type of moisture conservation technique is presented in Fig 3. This shows that soil moisture variation in 60cm and 30cm is very marginal due to homogeneous soil profile. Appreciable difference was found due to scattered rains in periods from p9 to p12 period. Little difference was found during p3 and p13 due to more rainfall of 6 and 8cm respectively. Quantity and Pattern of rainfall influence soil moisture variation in the soil profile. Analysis of dispersion by coefficient of variation indicates that degree of mean soil moisture fluctuation is moderately more at 60cm depth compared to 30cm irrespective of type of conservation technique.

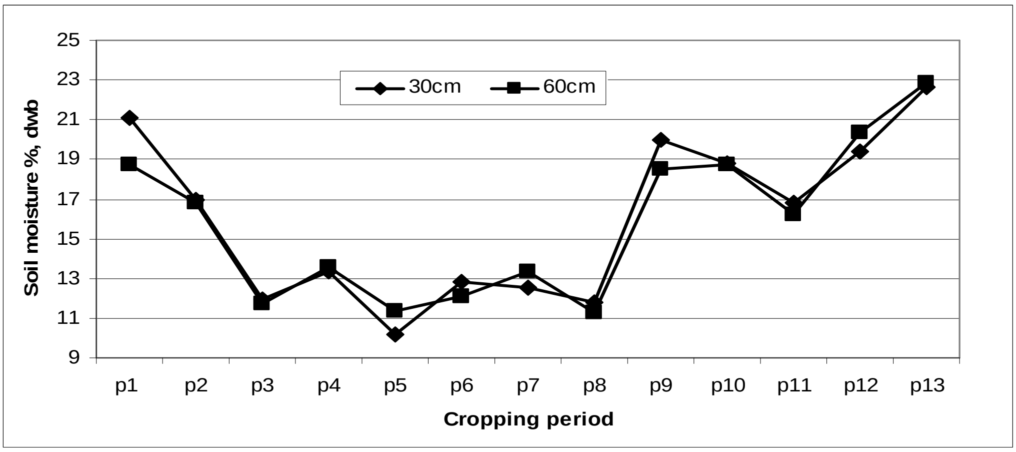

Fig 3 Variation of moisture in soil profile from June to October, 2007

5.3.3 Interaction effect of conservation techniques and periods at 30cm

Mean soil moisture data at 30cm obtained by analyzing the interaction of water conservation techniques and cropping period using Agres, is presented in Fig 4. It shows that the Ridges and furrows (t3) and compartment bund (t2) dominates in mean soil moisture throughout the cropping period compared to the plain land(t1). This dictates during rainfall periods, ridges & furrows and compartment bund harvest more rainfall and become dominant in soil moisture at 30cm depth.

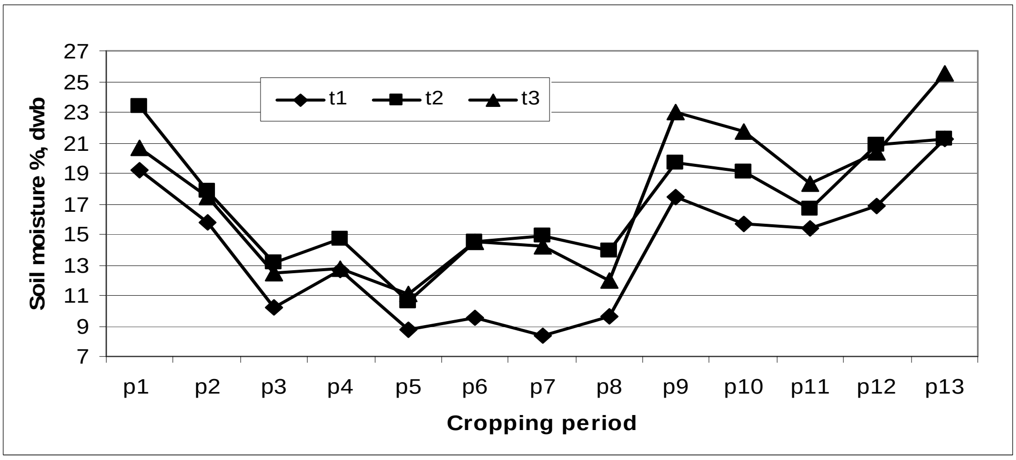

Fig. 4 Interactive effect of conservation technique and cropping period

Results of dispersion of soil moisture from mean are given in Table 2. Among the conservation techniques, plain land exhibits more fluctuation of soil moisture with coefficient of variation(Cv) of 31% and the fluctuation is minimum in compartment bund with Cv of 22%.

Table 2 Statistical parameters of soil moisture% at 30cm depth

Statistical parameters	Plain land	Compartmental bund	Ridges & furrows
min	8.4	10.64	11.12
max	21.22	23.37	25.53
Standard deviation	4.31	3.73	4.74
Average	13.89	16.97	17.24
Cv%	31	22	27.49

5.3.3.1 Analysis of variance

Using the statistical software Agres, two factor analysis of soil moisture data at 30cm depth for different periods under different water conservation techniques was performed to decide the best conservation technique. It shows that water conservation techniques irrespective of cropping periods have significant variation of mean soil moisture at 99% confidence level. Interacted effect of conservation technique and cropping period on soil moisture is not significant. Based on mean comparison, group A comprising compartment bund followed by Ridges & furrows has the best performance and Group B comprising plain bed has the poorest performance.

5.3.4 Interaction effect of conservation techniques and periods at 60cm

Mean soil moisture data at 60cm obtained by analyzing the interaction of water conservation techniques and cropping period using Agres, is presented in Fig 5. It shows that the Ridges and furrows dominate in mean soil moisture followed by compartment bund.

Results of dispersion of soil moisture from mean are given in Table 3. Among the conservation techniques, ridges & furrows and plain bed exhibited more fluctuation of soil moisture with coefficient of variation (Cv) of 26% and the fluctuation is minimum in compartment bund with Cv of 22%. Both compartment bund and ridges & furrows showed more mean soil moisture of around 16%. In general it can be concluded that both the ridges & furrows and compartment bund performed better compared to plain bed.

Table 3 Statistical parameters of soil moisture% at 60cm depth

Statistical parameters	Plain land	Compartmental bund	Ridges & furrows
min	9.07	11.78	11.14
max	20.4	23.03	25.23
Standard deviation	3.71	3.70	4.65
Average	14.21	16.27	17.31
Cv %	26.14	22.76	26.88

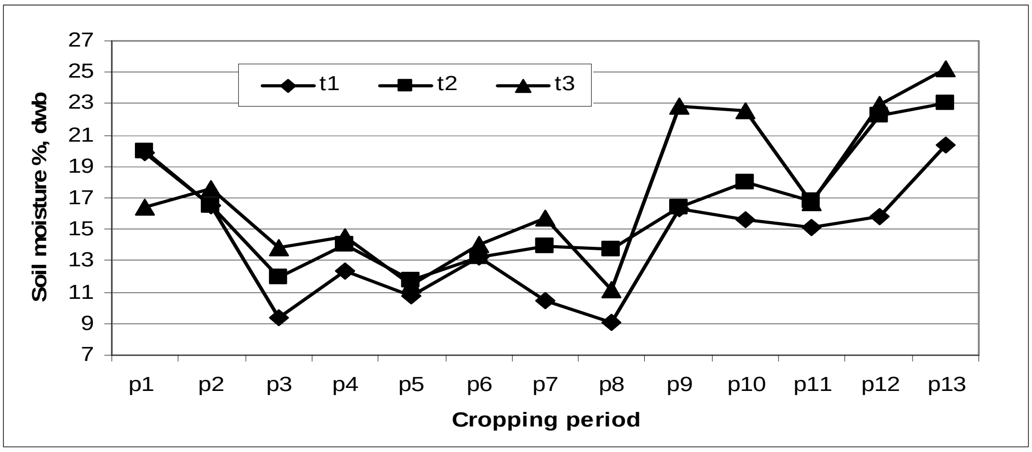

Fig. 5 Interactive effect of conservation technique and cropping period

5.3.4.1 Analysis of variance

Using the statistical software Agres, two factor analysis of soil moisture data at 60cm depth for different periods under different water conservation techniques was performed to decide the best conservation technique. It shows that the water conservation techniques irrespective of cropping periods have significant variation of mean soil moisture at 99% confidence level. Interacted effect of conservation technique and cropping period on soil moisture is not significant as the case of 30cm. Based on mean comparison, Group A comprising of Compartment bund followed by Ridges & furrows has the best performance and Group B comprising of plain bed has the poorest performance.

5.4 Analysis of soil water dynamics

Data collected on rainfall, pan evaporation, soil moisture and field capacity in the experimental fields during the study period are used to analyse water balance components in 90cm soil depth which is the effective root zone of maize crop. Compartment bund which is found as the best conservation technique, ridges & furrows and the poorest performing plain land are considered for water balance analysis. Results of the analysis are presented in Fig 6, 7 and Fig 8. Actual soil water and available deficit water in the soil are the parameters analyzed. Deficit water from field capacity has high coefficient of variation of 42% in ridges & furrows followed by 28% in compartment bund indicating the degree of influence by rain water.

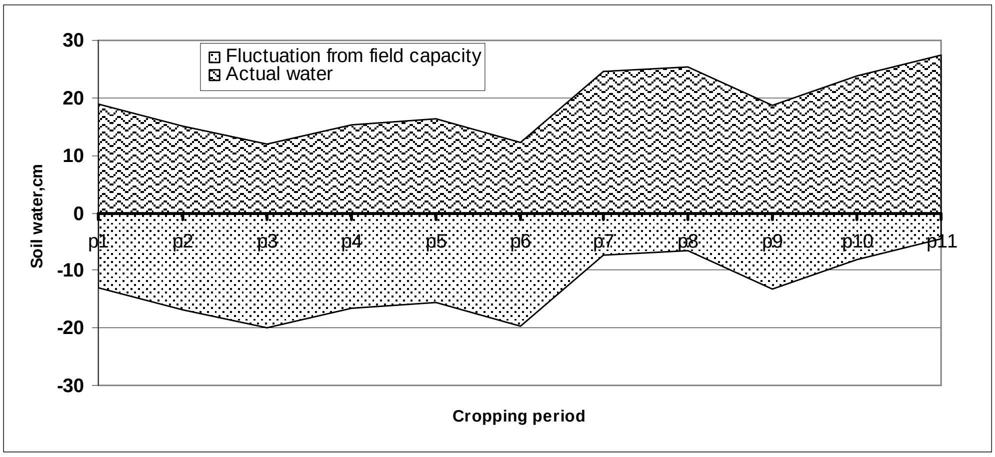

Fig 6 Variation of soil water in 90cm depth for Ridges and Furrows

In all techniques the actual soil water during the entire cropping period remains below field capacity posing soil moisture stress. In ridges & furrows and compartment bund the actual soil water is somehow approaching the field capacity at the end of the cropping period due to onset of rain.

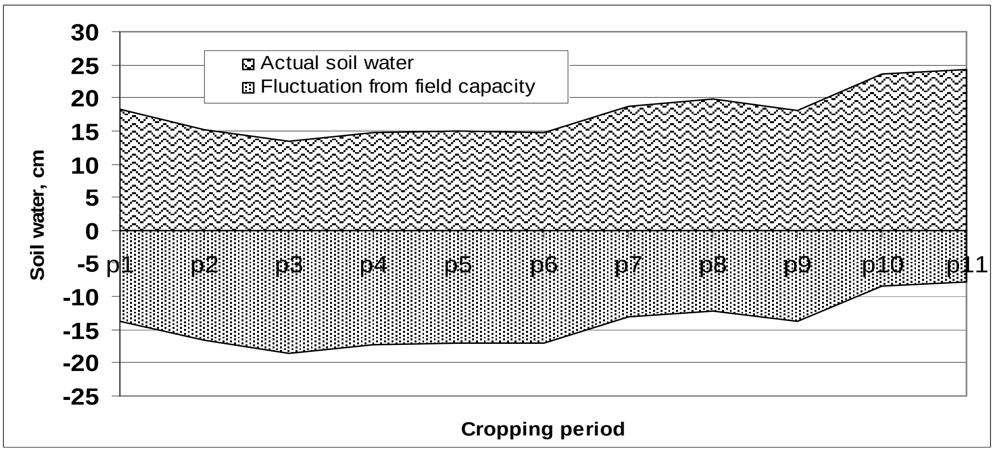

Fig 7 Variation of soil water in 90cm depth for compartment bund

Plain bed exhibits low degree of fluctuation of deficit water indicating poorly influenced by rain water as compared to other techniques. And also sometime in this treatment the soil water was below wilting point. Statistical parameters of actual soil water and deficit water from field capacity for all the conservation techniques are presented in Table 4.

Table 4 Statistical parameters of soil water and deficit water

Statistical parameters	Plain bed		Compartment bund		Ridges & furrows	
	Actual soil water cm	Deficit water cm	Actual soil water, cm	Deficit water, cm	Actual soil water cm	Deficit water cm
Average, cm	14.91	16.99	17.8	14.10	19.07	12.83
Standard deviation, cm	4.0	4.0	3.63	3.63	5.45	5.45
Coefficient of variation %	26.78	23.51	20.37	25.71	28.61	42.50

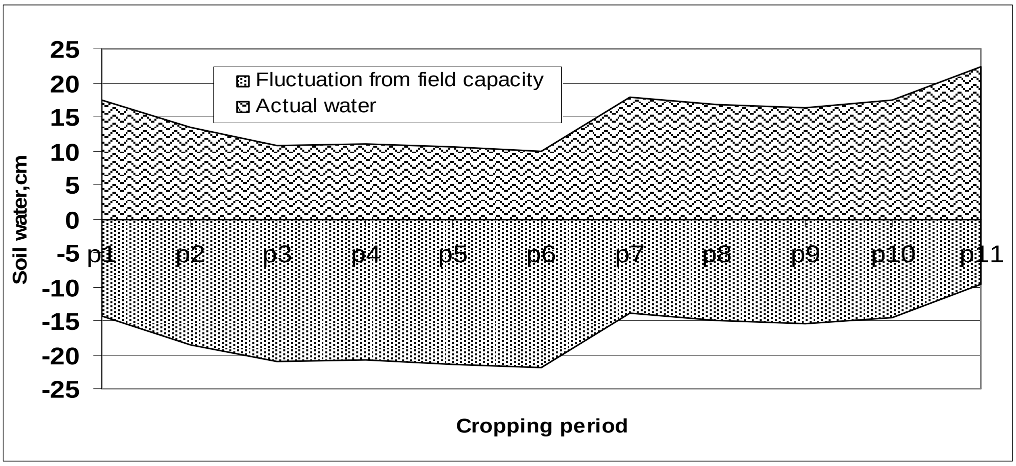

Fig 8 Variation of soil water in 90cm depth for plain bed

5.5 Soil water depletion% and available soil water

Figure 9 shows the difference in variation of depletion% among the conservation techniques and plain land shows more soil water depletion because of poor rain water harvest compared to other treatments.

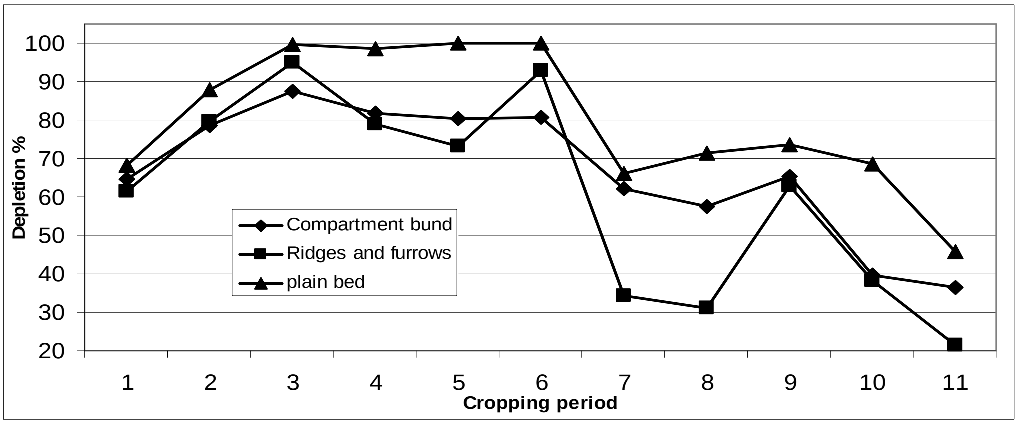

Fig 9 Variation of depletion % between treatments

Variation of available water in all the conservation techniques against crop water demand has been presented in Fig 10. Compartment bund and Ridges & furrows followed by the plain land have available water more than the crop water demand during flowering to harvest stage. Vegetative stage of the crop suffered with soil moisture stress in all the techniques resulting failure of yield. Flowering was observed in period P7 when available soil water was more than crop water demand posing no soil water stress. But no maize yield was recorded in all the techniques because the soil water depleted to 60% and above from the beginning of the cropping period.

Soil moisture content at 90 cm soil depth at field capacity and wilting point are taken as 31.1cm and 10.8cm respectively. Maximum available water for the crop is 21cm. Plain bed reached 100% depletion from field capacity particularly during vegetative and early mid stages whereas compartment bund and ridges & furrows remained with more than 70% depletion. This clearly demands supplementary irrigation particularly during periods from p2 to p7.

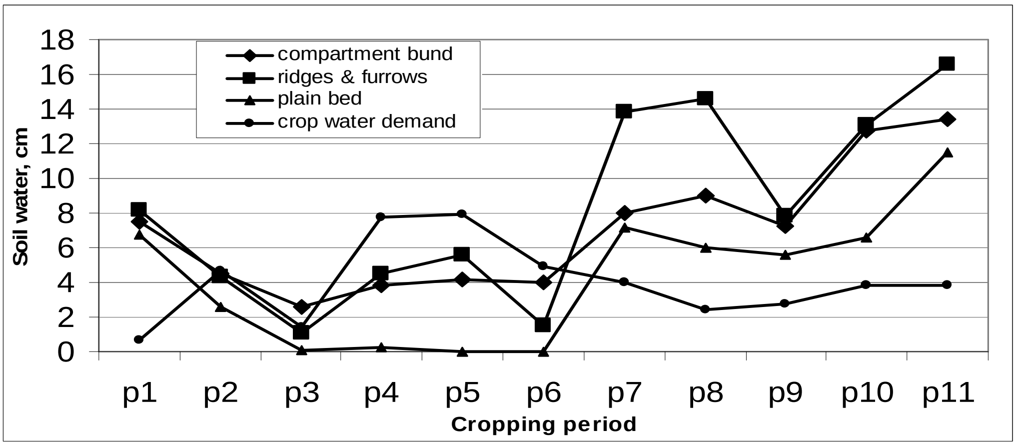

Fig 10 Available soil water and crop water demand

Considering the best recommended moisture conservation technique of compartment bund depletion % of soil moisture from field capacity during different growth stages of maize crop is presented in Fig 11. It varies from 60 % to 85% during development and mid stages which demands supplemental irrigation.

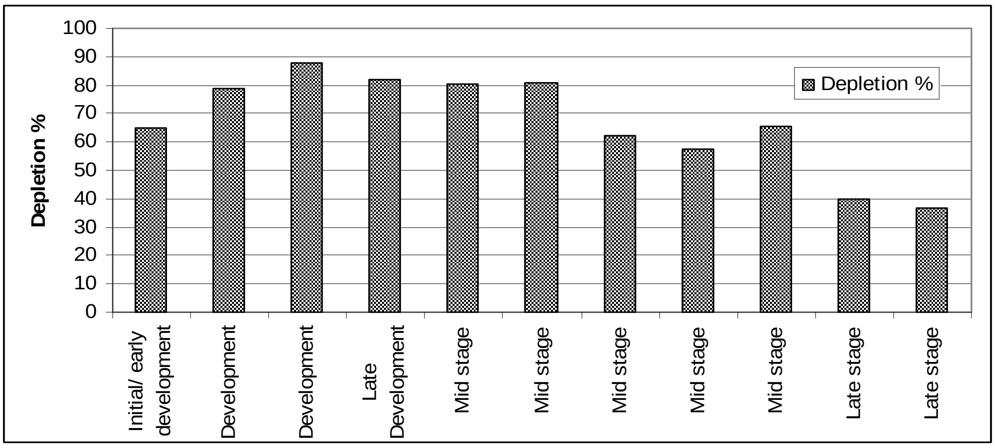

Fig 11 Depletion % at different growth stages of maize in compartment bund

5.6 Efficiency of moisture conservation

For the entire cropping period, efficiency of moisture conservation has been calculated from initial, final soil moisture content and total rainfall received. Results are summarized in Table 5. Ridges & furrows conserved with a maximum of 85.8 % efficiency in terraced land. The unterraced field showed very poor efficiency of 13.9% and indicates the importance of bench terraces for soil moisture conservation.

Table 5 Efficiency of moisture conservation

Treatment	Unterraced	Terraced-Plain	Terraced-RF	Terraced-CB
Efficiency of moisture conservation, %	13.9	69.8	85.8	75.9

5.7 Agronomic parameters

During the study, plant height, stem circumference and number of leaf had been recorded and summarized in table 6. It shows that the compartment bund is the best technique followed by ridges & furrows and supported good plant growth compared to the plain bed. Because of water stress during vegetative stage in all the treatments, the crop failed to yield.

Table 6 Summary of agronomic parameters

Conservation Techniques	Plant height, cm		No. of leaf		Stem circumference, cm	
	27/7/2007	27/8/2007	27/7/2007	27/8/2007	27/7/2007	27/8/2007
Plain bed	42.33	125	7	9	1.8	3.37
Compartment bund	61.06	171.8	9	11	2.4	4.05
Ridges & Furrows	53	136.2	8	10	2.28	3.54

6.0 CONCLUSION

Occurrence of timely rainfall in sufficient quantity is the prime requirement for successful rainfed agriculture. Insufficient rainfall during dry season attracts the need of water harvesting and soil moisture conservation. The study has been conducted in ISAE terraced farm at Rubirizi with the objective of evaluating in-situ soil moisture conservation techniques to support crop planning and water management.

The study explores the best technical option to resolve the constraints related to water management in rainfed farming. Comparative study of in-situ soil moisture conservation techniques in terraces and unterraced field with maize crop had been conducted from June 2007 to October 2007. Analysis of rainfall and crop water demand indicates that it is inevitable to provide supplemental irrigation and in-situ moisture conservation for successful crop in this region. Bench terrace increased the average soil moisture content in 90cm soil depth by more than 50% than that of unterraced land. Within the bench terraced field compartment bund increased soil moisture by 18.2% higher the plain bed with a coefficient of variation of 20.6% and ridges & furrows increased by 27.8% with coefficient of variation of 29.3%. This indicates that in-situ moisture conservation measures are effective to increase soil moisture compared to plain bed. It is also found that mean soil moisture fluctuation in the soil profile is moderately more at 60cm depth compared to 30cm irrespective of type of conservation technique.

Performance of ridges & furrows, compartmental bund and plain land was evaluated in terms of soil moisture conservation. The study reveals that Compartment bund performed well in both 30cm and 60cm soil depths followed by ridges & furrows because of consistent soil moisture as evidenced by less coefficient of variation. Higher moisture content in these two techniques is due to water barrier to harvest rainwater. Average soil moisture content for compartment bund and ridges & furrows varied between 16 to 17% and 13 to 14 % for plain bed at both 30 and 60cm soil depths.

In all the three techniques, actual soil water during the entire cropping period remained below field capacity posing soil moisture stress. No maize yield was recorded in all the techniques because the soil water depleted to 60% and above from the beginning of the cropping period inferring the need of supplementary irrigation. Plain bed exhibited lowest degree of fluctuation of deficit water indicating poorly influenced by rain fall as compared to ridges & furrows and compartmental bund. In terms of efficiency of moisture conservation during the cropping period, ridges & furrows performed well with 85.8% followed by compartment bund with 75.9% in terraced field. Unterraced field conserved moisture very poorly with 13.9% efficiency inferring importance of bench terraces for soil moisture conservation.

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