EFFECT OF MICRO-CATCHMENT RAINWATER HARVESTING ON YIELD OF MAIZE IN A SEMI-ARID AREA

B. Kayombo[A], N. Hatibu[B] and H. F. Mahoo[B]
[A] Department of Agricultural Engineering and Land Planning, Botswana College of Agriculture, Gaborone, Botswana
[B] Department of Agricultural Engineering and Land Planning, Sokoine University of Agriculture, Morogoro, Tanzania

Abstract
Experiments were run between 1992 and 1996 in a semi-arid zone of Mwanga District of Kilimanjaro Region, Tanzania, to assess the performance of maize grown in micro-catchment systems with Catchment to Basin Area Ratio (CBAR) varying from 0:1 to 4:1 Maize var. TMV1 was used as a test crop. Grain was harvested in five out of six experimental seasons (viz. *Masika* 1993, 1994 and 1995, and *Vuli* 1994/95 and 1995/96). The results showed that micro-catchment rainwater harvesting (RWH) farming is feasible during *Vuli*. The yield benefits due to RWH were found to be 120-152% and significant at P=0.05. An increase of CBAR resulted in higher yields. The CBAR used in this study were, however, rather low.

Additional keywords: catchment, basin area ratio

Introduction
A research project titled "Evaluation and Promotion of Rain-Water Harvesting", some of the results of which are reported in this paper, was conducted in Tanzania during the period 1992 - 1996. The aim of the project was to increase sustainability of production of flood-and-drought prone semi-arid lowlands through more effective management or rainwater. Kilimanjaro Region was chosen as a major research area because it has its population concentrated on the top belt and slopes of the mountain ranges. The area has the highest population density in Tanzania (2002 census); and with the heavy concentration of population in he highlands, the land has reached its maximum agricultural potential. The present government policy is to encourage people to shift from the highlands and slopes to the low semi-arid lands. The success of this policy however, depends on increased water supplies in the semi-arid lowlands to enable the farmers to grow the crops they are used to. A review of rainwater harvesting techniques and their use (Gowing *et al.*, 1999) has shown that there is a widespread practice of rainwater harvesting in Tanzania.

Rainwater harvesting with storage of water for livestock has received government support in the past. However, many storage reservoirs have been destroyed by siltation. On the other hand rainwater harvesting for crop production has not received an adequate support from research and extension services (Gowing et al. 1999). The challenge is to identify and disseminate appropriate technologies that will reduce vulnerability to rainfall variability and scarcity in the semi-arid areas. The purpose of thus paper is to assess the effectiveness of micro-catchment systems in the performance of maize grown in a sem-arid area.

Materials and Methods
The experiments were conducted in the semi-arid zone of Mwanga District in Kilimanjaro Region. The experiments were located at Kisangara within the semi-arid Western Pare lowlands (WPLL). The site was located at 37 35S at an altitude of 870 m above mean sea level. The area was under sisal production since 1975. The sisal plants were cleared in 1993 by a front-mounted shear blade bulldozer, before setting up the experiments. The dominant soil occurring in the Kisangara experimental site is *Luvisol*. *Ferric Luvisol* occupies nearly 90% of the experimental site (Ngatoluwa *et al.*,1995). These soils occur intensively on the middle and the lower slope position. *Ferric Cambisol* and *Plinthic Luvisol* cover approximately 8% of the experimental area. The remaining 2% is occupied by small pockets of *Chromic Luvisol*.

The experimental layout was split into two different slopes of 3 and 8%. Randomized Complete Block Design (RCBD) with three replications was used. The treatments were as shown in Table 1, and the layout was as illustrated in Figure 1. The cultivated basins were 50 m^2 and were 10 m long and 5 m wide. The catchments were also 5 m wide, and the different CBARs were achieved by varying the length of the catchment.

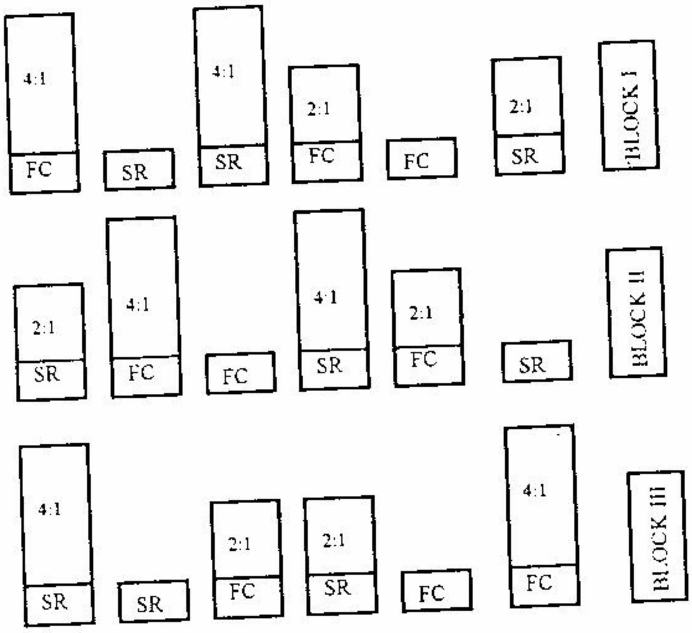

Figure 1. Experimental layout

Table 1. Description of treatments

Tillage practice on the CB	CBAR	Treatment
Flat Cultivation (FC)	0:1	T1
	2:1	T2
	4:1	T3
Staggered Ridging (SR)	0:1	T4
	2:1	T5
	4:1	T6

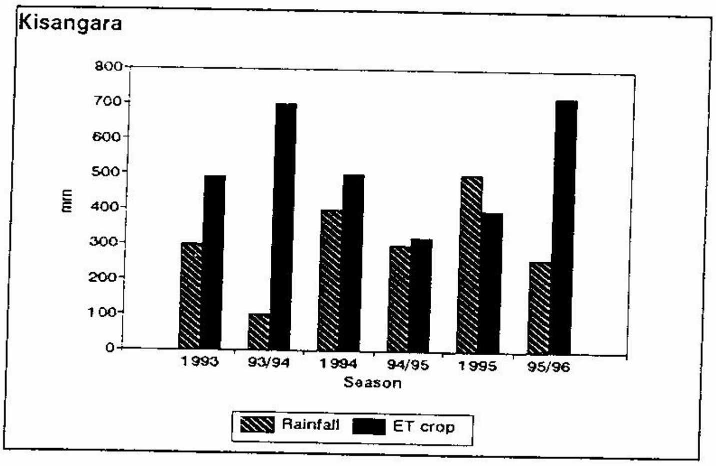

Figure 2. Comparison of seasonal rainfall and Etcrop (maize) during the experimental period

Maize (*Zea mays* L. var TMV1) was used as a test crop. The crop was sown at a rate of two plants per hill. At sixth leaf growth stage, the crop was thinned to one plant/hill giving a plant population of 45000 plants ha^{-1} with spacing of 0.75 m between rows and 0.3 m between plants. Fertilizer TSP at a rate of 40 kg P ha^{-1} was applied at sowing, and N fertilizer was applied at a rate of 40 kg N ha^{-1} at six-leaf growth stage. Tillage was implemented by hand hoe to a depth of 10 cm. A “U” shaped bund was constructed around each cultivated basin to a height of 15 cm. Ridges were constructed with staggered openings, for spreading harvested water.

Rainfall data was collected using a recording rain gauge located 1.5 km from the site. This may have created some problems, as the rainfall in these areas is known to vary substantially over short distances (Ngana, 1991). To overcome this problem a non-recording rain gauge was also used at the site. Evaporation and temperature data was also collected. Moisture content was nominated using a neutron probe through an access tube in the centre of each cultivated basin. Crop growth was monitored through biomass harvest at 6^{th} leaf and at silking stages. Stover and grain yields were determined by harvesting 15 m^2 of well-bordered sample plots. All stover and grain were dried at 60ºC until constant weight was obtained.

Descriptive analysis was used to compare long-term means and seasonal effect on grain yield. Analysis of variance (ANOVA) was used to test the effect of treatments on both biomass and grain yields.

Results and Discussion

Effect of catchment to basin area ratio (CBAR) on grain yield

Grain yields generally increasing CBAR ratio (Table 2). For example, there was an increase of 17% for CBAR of 4:1 over the control, during *Masika* (i.e long rainy season), while the increase during *Vuli* (i.e short rainy season) for the same CBAR was 152%. Therefore, the yield increase benefits obtained from miro-catchment RWH are low during *Masika*. The main reason is that the crop water requirement is adequately met during this season (Figure 2). This explains the minimal effect obtained from addition of water. During *Vuli*, the benefits from RWH were large indicating that soil-water available to plants was limiting. However, the low overall yields compared to *Masika* indicate that the CBAR used in this study were too low. Similar trends have been reported in Kenya (Critchley, 1989; Kilewe and Ulsaker, 1984).

Table 2. Effect of RWH on long-term grain yield means

	CBAR	Mean grain yield (kgha^{-1})	% increase due to RWH
Masika	0:1	2, 324.1a	
	2:1	2, 593.0a	12
	4:1	2, 709.8a	17
Vuli	0:1	385.4b	
	2:1	847.8a	120
	4:1	970.1a	152

Tillage practice effects

The tillage practise of the cultivated basin had some effect on the grain yield. The main grain yield from flat cultivation was 2683 kg ha^{-1} and staggered ridges being only 2401 kg ha^{-1} (Table 3). The difference in yield was significant (P=0.05) during only a few of the seasons.

Seasonal effects

Seasonal effects on grain yield were observed. The grain yield was high during Masika with an average of 2542 kgha^{-1} as compared to Vuli season with average yield of 734 kg ha^{-1}. There was both significant difference between the season and treatment at P=0.05 (Table 4). All treatments had significantly (P=0.05) higher grain yield during *Masika* than the corresponding treatment in *Vuli*.

Seasonal effects

Seasonal effects on grain yield were observed. The grain yield was high during Masika with an average of 2, 542 kg ha^{-1} as compared to Vuli season with average yield of 734 kg ha^{-1}. There was both significant difference between the season and treatment at P=0.05 (Table 4). All treatments had significantly (P=0.05) higher grain yield during *Masika* than the corresponding treatment in *Vuli*.

Table 3. Effect of tillage practice on grain yield (kg ha^{-1})

Season	Tillage Practice	1993	1994	1995	Mean
Masika	FC	1844.3	3047.0	3159.0	2683.4
	SR	1209.7	2902.3	3091.1	2401.1
Vuli	FC	-	865.7	769.3	817.5
	SR	-	671.1	631.2	651.3

Table 4. Seasonal effects on grain yield (kg ha^{-1})

Treatments	Masika	Vuli
T1	2502.3	361.3b
T2	2145.8	409.5b
T3	2779.2	1079.5a
T4	2406.8	616.0ab
T5	2768.8	1011.8a
T6	2650.7	928.5a
Mean	2542.3	734.4

Table 5. Effect of slope on grain yield (kg ha^{-1})

Slope (%)	Masika	Vuli
3	2866.0	514.1
8	2664.8	954.0
	NS	NS

NS = Not significant at P=0.05

Conclusion

Micro-catchment RWH significantly increased the grain yield of maize in a semi-arid area. The yield increase benefits were greater during Vuli compared to those of Masika. An increase in CBAR resulted in higher yields, the highest yield being obtained with a CBAR of 4:1. The CBAR used in this study were, however, rather low.

References

Critchley, W. R. S.(1989). Runoff harvesting for crop production: Experience in Kitui District 1984 - 1986. In: D. B. Thomas, E. K. Biamah, A. M. Kilewe, L. Lundgren and B. O. Mochonge (Editors), Soil and Water Conservation in Kenya. *Proceedings of 3rd National Workshop*, Kabete, Nairobi, 16 - 19 September 1986, University of Nairobi and SIDA, Nairobi, pp 396 - 406.

Gowing, J. W., Mahoo,H.F., Mzirai,O.B. and Hatibu,N.(1999). Review of rainwater harvesting Techniques and evidence for their use in semi-arid Tanzania. *Tanzania Journal of Agricultural Sciences* 2(2), 171 - 180.

Kilewe, A. M. and Ulsaker,J.P.(1984). Topographical modification of land to concentrate and Redistribute runoff for crop production, *East African Agricultural and Forestry Journal* 44, 257 - 265.

Ngana, J. O.(1991). Selection of probability distribution for estimating reliably seasonal rainfall in semi-arid central Tanzania, Research Report No. 79, Institute of Resource Assessment, University of DaresSalaam, 23pp.

Ngatoluwa, R. T., Mansoor,H.A. and Nyaki,A.S.(1995). Report on soils of rainwater harvesting experimental site at Kisangara. Unpublished report, Soil-Water Management Research Programme, Sokoine University of Agriculture, Morogoro, 228 pp.