Technical Note on Performance of Macro-Catchment Rainwater Harvesting for Maize Production: Preliminary Results

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Introduction

Macro-catchment rainwater harvesting (RWH) describes those techniques with much larger Catchment Areas (CAs) (generally > > 1ha) which generally do not fall within a farmer's land. The CAs and Cropped basins (CBs) will often be very different in character and the transfer distance may be in the range of a few hundred metres to several kilometres. Although runoff efficiency is relatively lower than the microcatchment systems, runoff volumes will still be large because of the size of the CA. If the transfer distance is very large, it is also possible for the CA to receive rain and produce runoff for a CB which has received no rain. Macro-catchment RWH systems include: hillside systems such as the "majaluba" system of the Lake Zone of Tanzania (Meertens *et al.*, 1999) where water is channelled into bunded rice padis by small channels constructed across the slope on grazing land; stream-bed systems which spread water flowing in ephemeral streams using permeable stone dams or earth bunds (van Dijk and Ahmed, 1993); and stream diversion systems which channel water from ephemeral streams into water-spreading structures such as the "Caag" system of Somalia (Reij, 1991) The main problems with these systems are in controlling the sometimes very high volumes of runoff and preventing erosion. The risk of too much water washing away fields is a major problem in Western Pare Lowlands (WPLL).

Macro-catchment systems can be linked with roads or railway drainage systems. The nature of the drainage system is to concentrate runoff and direct it into culverts or bridges. However, often the systems are designed on basis of "save-the road- and -let-it flow "(Backman and Isaksson, 1994). As a consequence, the concentrated run-off is left to cause gully erosion downstream of a road or railway line.

The experiment reported here was designed to test methods for harnessing run-off from road culvert for supplementary water supply to maize fields.

Methodology

The experiment was located at Kifaru village in Mwanga District. Water was tapped from culverts on the Dar es Salaam - Arusha highway. The experiment had three treatments replicated three times– flat cultivation (FC), contour tillage and bunds (WC) and macro-catchment RWH (MC-RWH), on two soils in a partially randomised complete block design. The MC-RWH treatment involved diverting water from a road culvert/gully into a brick-lined channel (to minimise water losses). This channel ran down the southern side of each block and distribution boxes were used to divert first 1/3 , then ½ and finally all the remaining water into the three RWH plots on each soil. Because of inevitable losses in the distribution of the water, the RWH plots were excluded from the

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randomisation within blocks on the basis that the majority of variation in soil properties was likely to be down the slope (between blocks) and not across (with blocks). This is not ideal but was the most practical solution given limited resources. The macro-cacthment RWH experiments ran for one short rain season (*Vuli*) and two long rainy season (*Masika*) seasons from 1997 to 1999. Maize cultivar TMV1 was planted in two seasons but this was replaced with Kito in the final season because of a seed shortage.

Results and Discussion

Biomass yield

Comparison of biomass yield between treatments, seasons and fields are presented in Table 1. There was an increase in biomass yield with increased level of water management. Treatment FC produced the lowest yield in all three seasons while RWH produced the highest yield. However, analysis of variance showed that there was a significant difference (at P = 0.05) only in *Vuli* 1997/98.

Table 1: Biomass yield levels for three seasons

Field	Treatments	Biomass yield levels (kgha^{-1})		
		Vuli 1997/98	*Masika* 1998	*Masika* 1999
Upper Field	FC	4163 a	4809 a	4440 a
	WC	6035 ab	5360 a	4326 a
	RWH	7376 a	6213 a	5196 a
	CV%	17	18	10
	LSD $_{(P=0.05)}$	2201	2281	1019
Lower Field	FC	5643 bc	5467 a	4712 a
	WC	5664 b	5434 a	5072 a
	RWH	6743 a	5990 a	5125 a
	CV%	8	17	20
	LSD $_{(P=0.05)}$	1045	2125	2269

Grain yield

Maize grain yield levels for different treatments are shown in Table 2. Grain yields for RWH treatment were higher for all seasons and fields. Analysis of variance revealed that there was significant difference (at P = 0.05) in grain yields among treatments in all seasons, as follows:

Table 2 Maize grain yield levels at Kifaru site for three seasons

Field	Treatments	Grain yield levels (kgha^{-1})		
		Vuli 1997/98	*Masika* 1998	*Masika* 1999
Upper Field	FC	1949 b	1872 a	2227 b
	WC	2738 ab	2150 a	1932 c
	RWH	3022 a	2626 a	2456 a
	CV%	18	17	2
	LSD $_{(P=0.05)}$	1054	866	119
Lower Field	FC	1747 b	1492 b	2172 a
	WC	2207 ab	1975 ab	2350 a
	RWH	2450 a	2525 a	2530 a
	CV%	12	22	20
	LSD $_{(P=0.05)}$	591	990	1046

(i) Short rainy season *(Vuli)* 1997/98

During this season there was significant difference in grain yield on both upper field (F1) and lower field (F2). MC-RWH and WC treatments produced a higher grain yield than FC. However, there was significant difference only between MC-RWH and FC. Grain yield difference can be explained by the difference in root-zone moisture content presented in Table 3. The amount was on average higher on plots with RWH treatments.

Table 3: Root zone soil moisture (v/v %) during *Vuli* 1997/98 growing season

Days after planting	Treatments					
	Field-F2			Field-F1		
	FC	WC	RWH	FC	WC	RWH
18	27.8	29.1	29.0	25.0	25.5	24.9
29	26.4	30.5	32.7	20.8	22.6	21.9
41	20.4	22.6	19.6	14.2	14.0	14.7
53	23.8	29.7	29.5	16.7	19.4	22.5
66	34.7	43.1	43.0	28.4	29.7	30.6
77	29.6	34.1	34.8	14.6	15.8	16.5
89	27.9	34.0	35.5	30.9	31.9	33.6
101	25.1	27.3	31.0	21.1	20.5	25.7
111	22.6	25.6	28.0	21.9	23.1	26.4
Average	26.5	30.7	31.5	21.5	22.5	24.1

LSD for the average is 13.39 (P = 0.05)

(ii) Long rainy season *(Masika)* 1998

During this season which was rather dry, significant difference in yield were observed only in the lower field (F2). In this case the RWH treatment produced grain yields which were significantly higher than those obtained from the FC treatment (Table 2).

(iii) Long rainy season *(Masika)* 1999

Grain yield differences were significant only in the upper field F1. In this case the plots with RWH yielded significantly higher than both the other treatments.

The results from the three seasons show that there is an increased grain yield with RWH. This benefit ranges from 180 kgha^{-1} to 1,073 kgha^{-1} and was consistently observed in all seasons and fields. Work in Kenya in mid - 1980, also showed similar trends in the performance of maize (Critchley, 1989). Another study in Kenya showed that the use of macro-catchment RWH can increase by a factor of more than 2, the yield of sorghum, maize, green grams, cowpea, beans and cotton (Burgess, 1992). In their survey of rainwater harvesting for plant production in sub-Saharan Africa, Critchley *et al.* (1992) have described similar systems with similar or better performance. Work of the International Centre for Agricultural Research in Dry Areas (ICARDA) in the West Asia and North Africa (WANA) have shown that the yield of wheat can be increased by 2 - 3 tha^{-1} by using macro-catchment rainwater harvesting (Oweis, 1999).

Conclusion

There are considerable improvements on biomass and grain yields through application of run-off from gully flow especially when rainfall distribution is poor. However, this study was carried for only a short period where one year had abnormal high rainfall. Further experimentation is therefore necessary to fully explore the potential of macro-catchment RWH under a wider range of rainfall variations

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