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Effect of Some Micro-Catchment Water Harvesting Techniques on Soil Moisture Content Using Duncan's New Multiple Range Test

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Abstract

The experimental work was conducted at Jebel Awlia locality south of Omdurman city at a distance of 40 kilometer and 25 kilometers from the west bank of the White Nile River during two rainy seasons in an area of 5 hectares. The climate of the area is semi desert, characterized by high temperature of 45^{O}C during the summer. Wind speed is very high evoking dust. Very sparse herbaceous plants and *Acacia* trees comprise the plant cover which is green during the rainy season. The soil of the site is light to sandy soil. Four water harvesting techniques namely semi-circular, V-shaped, pits and deep ditches in addition to the control. These treatments were constructed before the onset of the rainy season and represented by three blocks. Soil moisture content was determined at three depths, namely 0 - 30, 30 - 60 and 60 – 90 cm. The measurements were carried out monthly during the conduction of the experiment.

Results showed that during both seasons, micro catchment techniques had significantly higher means of soil moisture content as compared to the control. On the other hand, among the micro catchment techniques the V-shaped micro

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catchment technique reported a significantly higher mean of soil moisture content for all months in both seasons as compared to the other techniques, followed by the semicircular, pits and deep ditch micro catchments, respectively. In all months, in both seasons, soil moisture content was significantly higher at 60 – 90 cm depth over 0 – 30 and 30 – 60 cm depths.

Keywords: Water Harvesting Techniques, Soil Moisture Content, Duncan's New Multiple Range Test.

INTRODUCTION

The challenge in arid and semi- arid regions is the low and uneven distribution of rainfall throughout the season, which makes rain fed agriculture a risky enterprise. Interest came up in recent decades to evaluate water management techniques most of them being simple, sure to implement and of low capital investment.

Dry hydro-climate; where water is a limiting factor for biomass production, combined together with fragile and inherently low fertile soils, implies higher degree of vulnerability *(Prinz and Singh, 2000)*. Degradation of rangelands; a main source of livelihood in arid environments, is generally linked to poor management of water resources and exploitation of vegetation cover. According to Handi *et al.*,(2003) water resources will steadily decline because of population growth, pollution and expected climate change due to the problem of global warming. Hence, the water crisis is getting more attention among all countries specially the developing ones. Therefore, new strategies and techniques dealing with water problems are highly needed.

A micro catchment is a specially contoured area with slopes and beams designed to increase runoff from rain and concentrate it in a planting basin where it infiltrates and is effectively "stored" in the soil profile. The water is available to plants but protected from evaporation. Micro catchment systems provide many advantages over other irrigation schemes. They are simple and inexpensive to construct and can be built rapidly using local materials and manpower.

Objectives:

1. To evaluate the efficiency of four different water harvesting techniques in retaining surface runoff and soil moisture content (micro catchment techniques).
2. Determine which water harvesting technique is suitable for this region.

MATERIALS AND METHODS

The experiment was carried out in an area of 5.0 hectares in Jebel Awila locality as a part of a programmer for revegetalion of the boundaries of Khartoum New

International Airport (KNIA) during 2010-2011 and 2011-2012 rainy seasons. The location of the experiment was south of Omdurman city at a distance of 40 kilometers and 25 kilometer from the west bank of the White Nile River. The climate of the area is semi desert, characterized by high temperature of 45^{O}C during the summer. Wind speed is very high evoking dust. Very sparse herbaceous plants and *Acacia* trees comprise the plant cover which is green during the rainy season. The soil is light to sandy in composition changes gradually to clay and sandy clay according to level and topography.

Four micro catchments techniques were randomly constructed in addition to control to investigate their effect as water harvesting techniques on soil moisture content. These techniques were as follows:

(1) Semi- circular water traps (T_1), which were designed with 30 m diameter, 90 cm high and 20 m apart between traps. The water dikes were composed of 3 units, and the dikes were 50 meters from the next unit of dikes.

(2) V-shaped water dikes (T_2): Each side was 30 meters long and at the bottom of the V-shaped dikes, the distance is also 30 meters. The distance between the set of dikes was 20 meters. The water trap was composed of 3 shapes at the front and 2 shapes at the rear at a distance of 50 meters between the front and rear.

(3) Pits (T_3): The pit was 5 meters wide, 10 meters long and 10 meters between pits. Pits were dug according to the land gradient. Water trap was composed of 3 pits at the front and 2 pits at the rear at a distance of 50 meters between the front and rear pits.

(4) Deep ditches (T_4)**:** The deep ditches were dug by a motor grader. The length of each ditch was 30 meters and depth of 90cm, at a distance of 20 meters between ditches. The water trap in this design was composed of three ditches at the front and two ditches at the rear, the distance between the front and rear ditches was 50 meters.

(5) The control (T_0): This is land without water harvesting technique.

Soil moisture content was determined at three depths (0 - 30, 30 - 60 and 60 - 90cm). Measurements were carried out monthly during the study period. The samples were oven dried at 105^{o}C in an electric oven for 24 hours and weighed to determine moisture content on dry basis as follows:

$$\text{Moisture content \%} = \frac{\text{wt of wet sample} - \text{wt of oven dry sample} \times 100}{\text{Wt of oven dry sample}}$$

Where: wt = the sample weight in gms.

Duncan's multiple range test, provides significance levels for the difference between any pair of means, each pair of means is compared against a different critical value which depends on the ranks of these means in the ordered array (Duncan, 1955).

RESULTS

Table 1 show that during both seasons, micro catchment techniques had a significantly higher means of soil moisture content as compared to the control, particularly in the months towards the end of the rainy season. For instance during October the percentage of increment in soil moisture content under the semicircular, V-shaped, pits and deep ditch micro catchments as compared to the control was about 92.8%, 127.2%, 78.3% and 68.3% for the 2010-2011 season and 92.8%, 109.0%, 81.1% and 43.2% for 2011-2-12 season, respectively. Whereas during April for both seasons, these treatments increased soil moisture content as compared to the control by about 5199.0%, 6399.0%, 4799.0% and 3699.0% and by about 8685.7%, 13328.6%, 7328.6% and 4900.0%, respectively (Table 1).

Among the micro catchment techniques, the V-shape micro catchment for all months in both seasons reported a significantly higher mean of soil moisture content as compared to the other techniques, followed by the semicircular, pits and deep ditch micro catchments. Soil moisture content under all micro catchment treatments as shown in Table 1 was higher during the second season than the first season.

In both seasons Table 2 shows that at all months, soil moisture content was significantly higher at 60 – 90 cm depth over the other two depths, followed by 30 – 60 cm and finally 0 – 30 cm depth. During October of the first season soil moisture content was higher under 60 – 90 cm depth as compared to 0 – 30 and 30 – 60 cm depths by about 17.6% and 9.0%, respectively, and by about 17.9% and 7.6% for the same month of the second season, whereas during April of the first season the percentage of increase in soil moisture content was about 42.4% and 17.5%, respectively and it was about 21.6% and 11.5% for the second season, respectively.

DISCUSSION

In this study, all micro catchment techniques during the study period (October – April) in both seasons registered a significantly higher mean of soil moisture content than the control. The higher values of this parameter were obtained in the order of the V-shaped, followed by the semi-circular, pits and finally deep ditch treatments. The significantly higher mean of moisture content under the micro catchment techniques as compared to the control may be attributed to the impact of these techniques on collection and storage potential of the surface run-off within the soil as well as reduction of evaporation due to the shape of the catchment.

These results were supported by those of Jianxin *et al.*, (2007) who stated that, micro catchment measures can intercept surface runoff and collect rain water and increase soil moisture. Also, Xiao *et al.*, (2005) found that moisture content was significantly higher under 24 micro catchments as compared to the control. Similarly, Abdelmajeed (2010) observed that soil moisture content was higher under micro catchment

techniques over the control, when the performances of 12 micro catchments were evaluated. Also at the upper Atbara River Seidahmed *et al.* (2012) noticed that the use of U-shaped as water harvesting technique resulted in a higher soil moisture content as compared to the control. Meanwhile, Tubeileh *et al.* (2006) showed that the construction of semi-circular and V-shaped bunds with up – and down – slope tillage furrows increased soil moisture content by about 4 – 15% than the control. Elboshra (2011) mentioned that both holes and crescents as micro catchment techniques positively affected soil physical properties such as porosity, field capacity and infiltration rate and hence moisture content. On the other hand, Singh *et al.* (2012) observed that soil moisture content increased by 17.8%, 16.1%, 24.2% and 14.0% for trench, gradonie, box trench and V-ditch techniques, respectively, when used as compared to the control.

Soil moisture content in this study significantly increased with depth. The depth 60 – 90cm showed significantly higher mean of soil moisture content over 30 – 60 and 0 – 30 cm depths for all micro catchments. The significantly higher mean of soil moisture content in the lower depth as compared to the upper ones may be due to the soil preparation during micro catchment construction as well as the effect of these techniques on the infiltration rate and their effect on water storage. Results were supported by those obtained by Seidahmed *et al.*, (2012) who observed that moisture content under U-shaped increased with depth from 0 – 20 up to 60 – 80 cm. Under moderate and light rain conditions Jianxin *et al.* (2007) found that moisture content was higher at 20 – 30 cm depth under both gradually constructed contour terrace and contour ridge as compared to the control, but at 0 – 10 cm depth there were little differences. Ali and Yazar (2007) reported that after 24 – 36 hours of rain water runoff, the soil moisture content under contour ridge (6×12 m spacing) was higher in layers lying between 15 – 45 depths. Tubeileh *et al.*, (2006) mentioned that all water gained by V-shaped bunds with up- and down- tillage furrows was stored in the layers below 40cm depth. Similarly Abdelmajeed (2010) showed that for 12 different types of micro catchment, soil moisture content was higher at 30 – 45 and 45 – 60 as compared to the same depths of the control.

The variation in soil moisture content between micro catchment techniques was also supported by many workers (Jianxin *et al.* 2007; Ngigi, 2008; Abdel Majeed 2010; Singh *et al.*, 2012). The high soil moisture content as shown for the V-shaped micro catchment could be attributed to the high efficiency of this technique to capture and store rain water runoff. Elboshra (2011) mentioned that holes as water harvesting technique showed better improvement of soil moisture content than the crescent shaped water harvesting technique. Ngigi *et al.* (2006) also found that conservation tillage practices increased soil moisture content as compared to the traditional tillage practices (mould board animal drawn ploughing) by about 25%.

CONCLUSION

1- All water harvesting techniques increased soil moisture content significantly.

2- Higher values of moisture content were recorded by the V-shaped water harvesting technique as compared to the other types of water harvesting techniques used in this study.

Table (1): Effect of micro catchment techniques on soil moisture content (by Wt) obtained at October to April during 2011/2012 and 2012/2013 seasons

Treatments	2011/2012							2012/2013						
	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	Oct.	Nov.	Dec.	Jan.	Feb.	March	April
T_0	10.34^{e}	4.13^{c}	1.84^{c}	0.17^{c}	0.06^{c}	0.01^{d}	0.00^{e}	11.12^{e}	10.90^{e}	8.44^{e}	2.01^{e}	6.85^{e}	1.34^{e}	0.14^{e}
T_1	19.94^{b}	11.12^{b}	8.92^{b}	7.34^{b}	6.37^{b}	5.50^{c}	5.20^{b}	21.44^{b}	23.52^{b}	22.72^{b}	19.23^{b}	22.48^{b}	15.80^{b}	12.32^{b}
T_2	18.44^{c}	12.64^{a}	9.64^{b}	7.86^{b}	6.72^{b}	6.33^{b}	4.79^{c}	20.14^{c}	22.57^{c}	21.05^{c}	16.92^{c}	20.06^{c}	12.64^{c}	10.36^{c}
T_3	17.36^{d}	10.97^{b}	9.89^{b}	7.40^{b}	6.15^{b}	5.63^{c}	3.70^{d}	15.87^{d}	17.47^{d}	13.13^{d}	11.34^{d}	14.03^{d}	8.39^{d}	6.98^{d}
T_4	23.36^{a}	13.36^{a}	11.43^{a}	9.77^{a}	8.58^{a}	7.42^{a}	6.35^{a}	23.15^{a}	26.69^{a}	25.95^{a}	23.79^{a}	26.76^{a}	21.23^{a}	18.75^{a}
S.E±	0.21	0.25	0.27	0.25	0.20	0.16	0.15	0.17	0.16	0.04	0.021	0.021	0.06	0.03

Means with the same latter(s) in the same column are not significantly different at 0.05 level of probability according to Duncan's New Multiple Range Test (DNMRT).

T_0= control; T_1= semi-circular; T_2= pits; T_3= deep ditch; T_4= V-shape.

Table (2): Effect of soil depths on soil moisture content (by Wt) obtained at October to April during 2011/2012 and 2012/2013 season.

depths (cm)	2011/2012							2012/2013						
	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	Oct.	Nov.	Dec.	Jan.	Feb.	March	April
0 – 30	16.53^{c}	9.03^{c}	6.70^{c}	5.10^{c}	4.54^{c}	4.03^{c}	3.32^{c}	16.83^{c}	18.48^{c}	16.60^{c}	12.92^{c}	16.09^{c}	10.75^{c}	8.82^{c}
30 – 60	17.77^{b}	10.36^{b}	8.35^{b}	6.47^{b}	5.58^{b}	5.00^{b}	4.01^{b}	18.39^{b}	20.26^{b}	18.16^{b}	14.42^{b}	17.83^{b}	11.79^{b}	9.61^{b}
60 – 90	19.37^{a}	11.94^{a}	9.98^{a}	7.95^{a}	6.60^{a}	5.90^{a}	4.69^{a}	19.81^{a}	21.95^{a}	20.01^{a}	16.63^{a}	20.19^{a}	13.10^{a}	10.71^{a}
S.E±	0.16	0.20	0.21	0.19	0.16	0.12	0.11	0.13	0.12	0.03	0.016	0.016	0.04	0.02

Means with the same latter(s) in the same column are not significantly different at 0.05 level of probability according to (DNMRT).

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