

Original Research Article

Effect of Water Harvesting Techniques (Holes and Crescents) on Growth of Sidr (*Ziziphus Spina-Christi*) In South Omdurman Area, Khartoum State, Sudan

Abstract

This study was conducted at south west Omdurman area, Khartoum state, Sudan, following a complete randomized block design, to study the effect of two water harvesting techniques (Holes- T₁ and Crescents- T₂) on the growth parameters of *Ziziphus spina-christi* and on soil moisture content. The growth parameters of *Ziziphus spina-christi* were measured at three weeks interval, the soil moisture content was measured before and after rains through the rain season from June to October. The results indicated that the water harvesting techniques WHT (holes T₁ and crescents T₂) affected positively on plant (Sidr) growth parameters as compared to control (C). The T₁ showed better improvement of plant (Sidr) growth parameters as compared to the T₂ WHT as it resulted in increase of 15.1% in soil moisture content, 3.3% in plant length, 9.1% in number of leaves per plant and 5.1% in plant stem diameter.

Key Words: Water Harvesting Techniques, Holes and Crescents, Sidr, soil moisture content, porosity, field capacity, infiltration rate.

INTRODUCTION:

Water conservation is one of the main challenges of agriculture, especially in rainfed areas. In arid and semi- arid regions distribution of rainfall is wobbling throughout the rain season in quantity and time which makes rain fed agriculture a very risky. United nation (2003) stated that water resources will steadily decline because of population growth, pollution and expected climate change due to the problem of global warming.

Water crisis is getting more attention among all countries specially the developing ones. Therefore, new strategies and techniques to deal with water problems are highly needed. Water harvesting (WH) and spreading techniques succeeded to providing a feasible solution for improving the living conditions of many millions of people facing serious water supply problems Shaker (2019).

WH is practiced at wide areas across the Sudan in low rainfall and high rainfall Savanna regions in traditional agriculture, human and animal use, as well as forest production in places having rainfall starting from 75 mm per annum. WH practices are actually found in most states of the Sudan. The effectiveness and efficiency of WH practices depend on factors such as soil type, rainfall, and crop Dawelbeit (2008).

According to Gould, (1999), Stoh, (2001) and Fentar *et al*, (2002) they defined WH as the collection and concentration of runoff for productive purposes as crop, fodder, pasture or trees production, livestock and domestic water supply in arid and semi-arid regions. For agricultural purpose, it is defined as a method for inducing, collecting, storing and conserving local surface runoff in arid and semi-arid regions.

Generally, water harvesting (WHT) techniques classified into two groups: micro and macro techniques. Micro-catchment methods also may be called on-farm systems (Oweis, 2001).

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Some of the most important purposes of using soil moisture conservation techniques, that it used as measures for achieving greater water use efficiency to enhance plant growth and produce more food with less water Kumawat et al. (2020). WHT, it used also to increase the period of moisture content in plant root zone after WH (Kumari and Singh, 2016), to conserve the soil from erosion, moisture deficit and loss of fertility (Saeed et al., 2019), to increase the survival rate of seedlings (Abedi-Koupai and Asadkazemi, 2006), and to reduce water losses by runoff and evaporation while maximizing in soil moisture storage for crop production (Gachene et al., 2019). Many rainwater harvesting structures are used to conserve soil and water in degraded lands, research findings have shown variability in their effectiveness for plant growth, biomass production, restoration of degraded lands, etc. Siyum et al (2019) , Derib, S.D (2009). Gebru, et al., (2019) stated that the moisture harvesting structures shows great potential in increasing tree survival and growth performance due to helping to harvest rainwater and protecting them. The objectives of this research paper are, to compare two different water harvesting techniques on the basis of soil moisture content (SMC), to promote the growth of an indigenous tree species (*Ziziphus spina-christi*) and to examine the viability of improving the physical condition of the soil.

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MATERIALS AND METHODS

- Site location:

This study was conducted at Khartoum New International Airport (KNIA) in the south western direction of Omdurman, Khartoum State at 15° 13' N Latitude and 32° 19' E Longitude, at a distance of about 40 km South of Khartoum center and 25 km west of the White Nile River.

- Rainfall:

The rainy season normally falls between July and September each year and the annual average rainfall is about 150 mm. Rains usually commence with relatively light showers but the effective rainy season starts in late June, increases in July and reaches its peak in August.

- Topography:

The topography of the study area is generally fairly flat but few isolated ridges and sand dunes may be observed in the western part of the site and the ground surface slopes gently to the east. The generally flat area of the site is confined by two wadies (shallow and relatively wide water course valleys).

- Vegetation:

Vegetation cover is dominated by poor desert and semi desert type with different distribution. Generally, the vegetation is dominated by some trees species of Acacias such as *Acacia tortilis* (sayal), *Acacia ehrenbergiana* (salm) and *Ziziphus spina-christi* (sidir), some bushes and some grasses included *Aristida plumosa* (Gabash), *Aristida mutabilis* (Gaw) and *Cassia senna* (sena kalib) Sona (2016).

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- Climate:

According to (Van der Kevie, 1973), The climate of study area is semi-desert to dry it is hot, dry and rainy during summer and cold dry in winter. rainfall during July and August. The average annual rainfall is 150 mm/year and the dry season covers 8-9 months. the daily average maximum temperature 37.7C° while the daily average minimum temperature 21.6C°. The daily evaporation rate is 7.7mm and the highest rate take place in April with average of 9.3mm. The daily mean of relative humidity is 38 at 1am and 21 at 2pm, while the mean wind speed is about 9 miles/hr

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- Soil:

The area is covered by a light brown and very thin gravely sand layer (about 10mm thick), and few angular to sub-angular, 20 to 60mm sized fragments of the ferruginous sandstone. The

southern part of the site is covered by sandy gravel probably formed due to the weathering of Nubian Group rocks which are outcropping in some places in the area. Cracks developed when the soil dries up by the end of the rainy season. Early rains penetrated into the soil of through these cracks before they close. Runoff usually occurs due to heavy rains.

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- **Experimental treatments:**

The experiment included two water harvesting techniques which were constructed before the onset of the rainy season; each treatment was represented by a block which included the plant species. Two types of water harvesting techniques were designed as follows

(a) Holes (Deep pits) technique (HT):

Each hole was 2.5 m in width, 4 m in length and 50 cm deep. The distance between holes in the row was 10 meters while the distance between rows was also 10 meters. The slope direction was made from the upper side to trap the sheet flow run-off after rain storms.

(b) Crescents or curved terraces technique (CT):

The diameter of crescent was 30 meters and 50 cm deep. The crescents are 15 m apart

(c) control

Seedlings:

The seedlings were raised in nursery to be about three months old when transplanted at the onset of the rainy season in July to give the seedlings the full benefit of the rainy season.

Planting:

The planting was performed by using holes sides and crescents. In holes the seedlings were placed at the side and the root zone was covered with fine soil. In crescents plot the seedlings were planted half way of the inner side of terrace as Shown in Plate 1 and 2.

Plant parameters measurements:

The following parameters were taken every three weeks starting from planting.

1. Plant height (cm):

Three plants were chosen at random from each treatment. Plant height for each plant was taken from the base of the plant to the top by using a metering device. The mean height of the three plants was recorded.

2. Number of leaves per plant:

Three plants were taken at random from each treatment so as to account the number of leaves per plant, and the mean number of the leaves of the three plants was recorded.

3. Stem diameter:

Three plants chosen at random from each treatment. Stem diameter was measured using a Vernia. The mean stem diameter of the three plants was recorded.

- **Equipment:**

The following equipment were used in the experiments:

- 1- A Loader was used construct the rain water harvesting structures.
- 2- Metering tab.
- 3- A vernier.

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- **Soil moisture content%**

Soil samples were taken from three depths, 0-30, 30-60, and 60-90 cm at three locations per by using the auger. Sampling was collected every month during the experiment in two seasons. Soil samples were weighed fresh and reweighed after oven dried at 105C° for 24 hours.

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$$\text{Soil moisture content\%} = \frac{\text{Soil fresh mass (g)} - \text{soil oven dry mass (g)}}{\text{Oven dry mass (g)}}$$

Where: wt = the sample weight in gms.

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3.11 Statistical analysis:

Data for each trial were analyzed as Complete Randomized Block Design (C.R.B.D) by standard analysis of variance techniques. Mean significant ($p \leq 0.05$) treatments were separated using Duncan's Multiple Range Test procedure (Steel and Torrie, (1980).

RESULTS AND DISCUSSION:

1. plant height

The result of plant height of tree showed in Fig.1 and Table 1. Analysis of variance for plant height for different time intervals under treatments showed no significant difference ($p \geq 0.05$) for all readings. The T₁ recorded best plant height in the 1st, 2nd, 3rd and equal in the 4th readings while the treatment T₂ recorded best height in the 5th, to 9th readings, this may be due to the high evaporation from T₂ and high soil moisture content in the T₁.

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When we compare the result of two treatment with control there is significant difference ($p \geq 0.05$) for all readings between treatments and control

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This result agrees with Muhsen (2021) and Sona (2016) that he was investigate the effect of water harvesting techniques on plant growth the result of shoot length for the three trees species, showed no significant difference. For all the readings the best height was given by *Acacia senegal* followed by *Ziziphus spina christi* and *Acacia tortilis subsp. raddiana*.

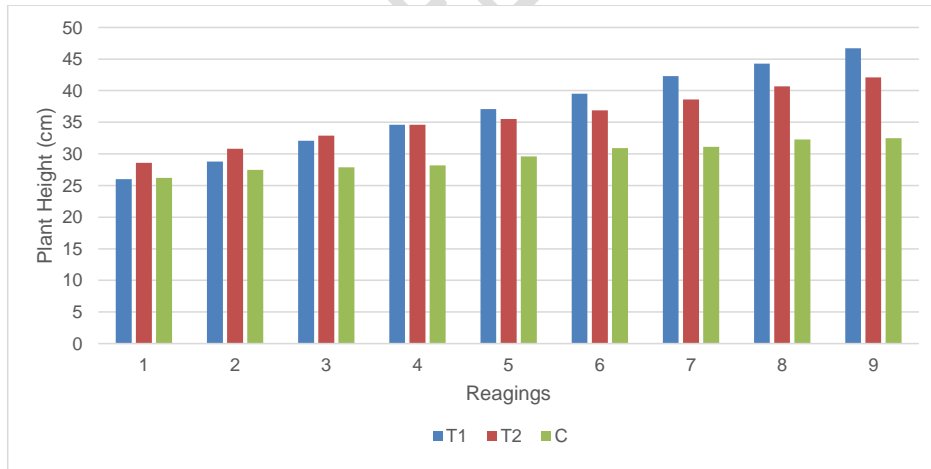


Fig.1: Plant height measurements

Table.1. Means of Plant height (cm)

Treatment	T ₁	T ₂	C
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Readings			
1	26	28.6	26.2
2	28.8	30.8	27.5
3	32.1	32.9	27.9
4	34.6	34.6	28.2
5	37.1	35.5	29.6
6	39.5	36.9	30.9
7	42.3	38.6	31.1
8	44.3	40.7	32.3
9	46.7	42.1	32.5

2. The effect of the experimental treatments on number of leaves per plant:

The data of means number of leaves are shown in Fig. 2 and table 2. Analyses of variance for number of leaves for different time intervals.

The analysis of variance for number of leaves showed in Tables (2) for the two treatments. The results showed no significant difference ($p \geq 0.05$) for all readings. This result agreed with the results obtained by Natheer, et al, 2017 and Sona (2016)

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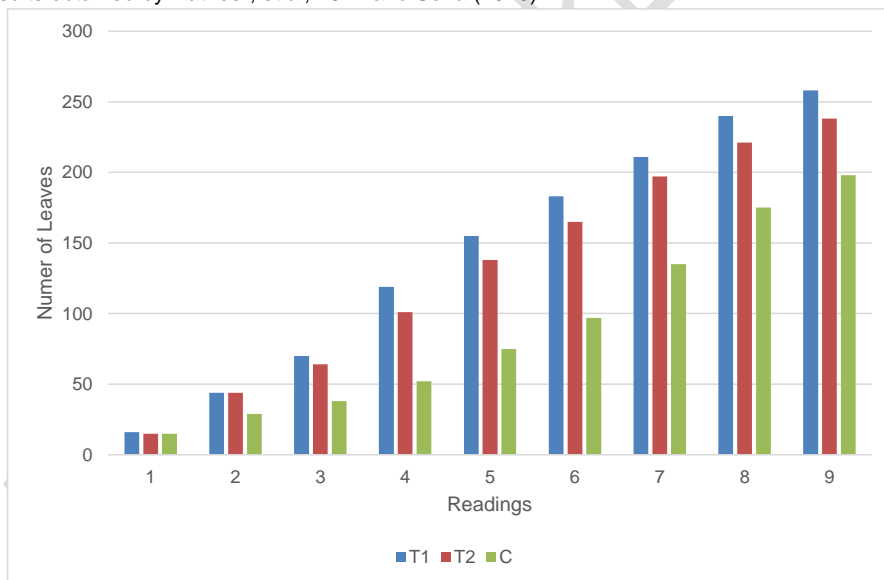


Fig.2: Number of leaves per plant measurements

Table.2. Means the Number of leaves per plant

Treatment	T ₁	T ₂	C
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Readings			
1	16	15	15
2	44	44	29
3	70	64	38
4	119	101	52
5	155	138	75
6	183	165	97
7	211	197	135
8	240	221	175
9	258	238	198

3. The effect of the experimental treatments on the stem diameter

one of the main important parameters that indicates the influence of the examined treatments on plants is stem diameter. The data of the stem diameter were shown in Fig. 3 and Table 3 Analysis of variance for stem diameter for different time intervals, The analysis of variance for stem diameter in the two treatments showed no significant difference ($p \geq 0.05$) for all readings. Generally, the results obtained for one location showed no significant difference among the treatments while Hamid (2004) recorded significant difference ($p \geq 0.05$) among treatments in three different locations.

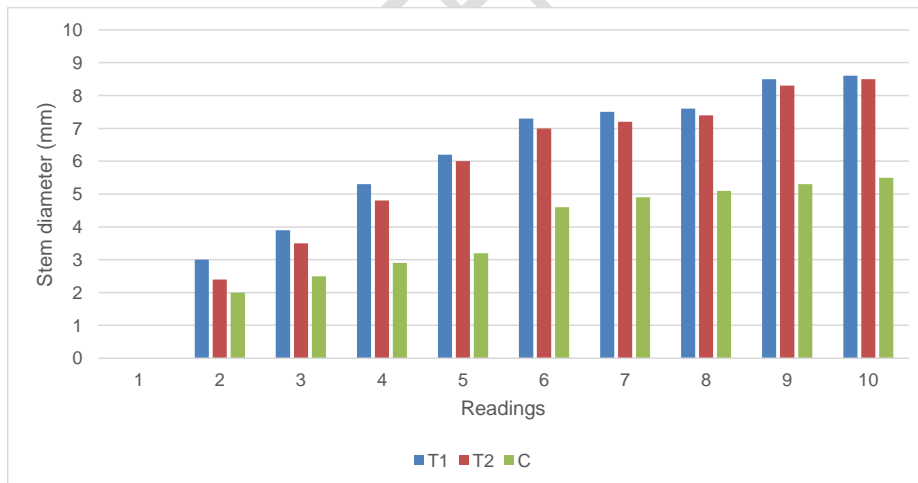


Fig.3: Stem diameter measurements

Table.3. Means of stem diameter (mm)

Treatment	T ₁	T ₂	C
Readings			
1	3	2.4	2
2	3.9	3.5	2.5
3	5.3	4.8	2.9
4	6.2	6	3.2
5	7.3	7	4.6
6	7.5	7.2	4.9
7	7.6	7.4	5.1
8	8.5	8.3	5.3
9	8.6	8.5	5.5

The effect of the experimental treatments on soil moisture content

The moisture contents of the soil before and after rain for different depths are shown in Fig 4 and Table 4. The analysis of variance for the soil moisture content for different depths and different time intervals for the two different treatments in the 1st reading before the rain showed a significant difference ($p \leq 0.05$) for depth (60-90), while the 2nd the 3th reading for depth (0-30) and (60-90), respectively after the rain showed a significant difference ($p \leq 0.05$) existed among the treatments. There was no significant difference ($p \geq 0.05$) for 4th, 5th, 6th, 7th, 8th and 9th readings showed for all depths. This result agreed with the results obtained by Azmi, *et al* (2015) who reported that all water harvesting techniques increased soil moisture content significantly, Sahar (2013) and Shiferaw *et al* (2020) he was mentioned that the use of water harvesting structures within land degradation projects shows both rise of soil moisture as well as an increase in biomass production of set species

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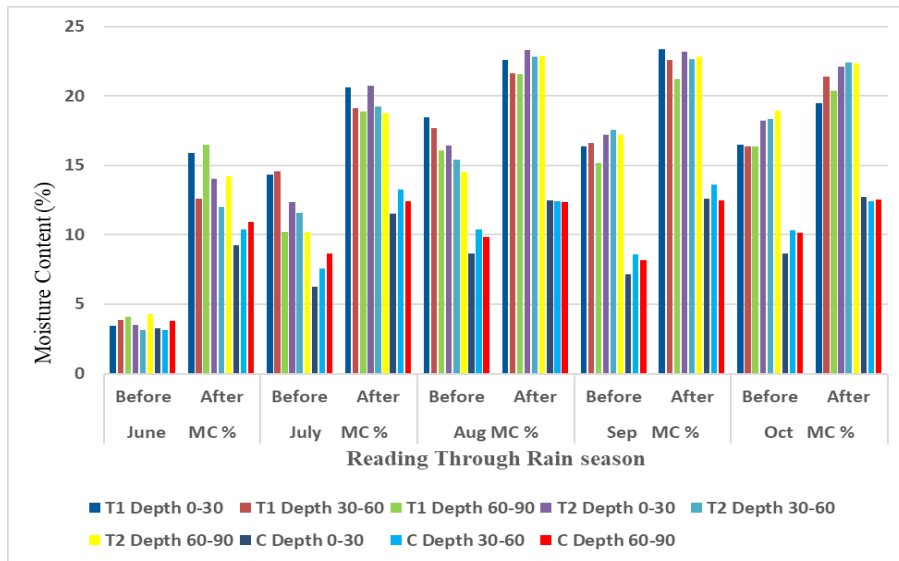


Fig.4: Soil moisture content (SMC) measurement (wt %)

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Table 4 Soil moisture content (SMC) measurement (wt %)

Treatment	Depth	June MC %		July MC %		Aug MC %		Sep MC %		Oct MC %	
		1	2	1	2	1	2	1	2	1	2
T ₁ Holes	0 - 30	3.45	15.89	14.36	20.6	18.46	22.6	16.4	23.4	16.5	19.5
	30 - 60	3.89	12.6	14.6	19.12	17.7	21.67	16.6	22.6	16.4	21.4
	60 - 90	4.12	16.52	10.2	18.86	16.1	21.56	15.2	21.2	16.4	20.4
T ₂ Crescents	0 - 30	3.50	14.06	12.36	20.75	16.45	23.34	17.22	23.22	18.22	22.15
	30 - 60	3.14	12.00	11.6	19.25	15.4	22.83	17.60	22.69	18.38	22.40
	60 - 90	4.28	14.22	10.2	18.78	14.5	22.92	17.2	22.84	18.93	22.35
Control (C)	0 - 30	3.25	14.23	10.20	16.26	9.69	15.20	8.28	15.20	10.13	14.30
	30 - 60	3.50	13.32	10.25	18.30	9.20	15.30	8.25	16.36	10.42	13.48
	60 - 90	4.43	13.50	10.52	18.45	10.40	16.40	8.55	16.52	11.60	13.51

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CONCLUSIONS

There was no significant difference in the plant growth parameters (number of leaves per plant, plant length and stem diameter) in any location due to water harvesting technique. The holes and crescents water harvesting techniques improved soil moisture content significantly. Higher values of moisture content were recorded for the holes type of water harvesting technique as compared to the crescents type. The *Ziziphus spina-christi* tree species is highly recommended in the west Omdurman area.

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