Original Research Article

Soil Water Conservation Methods Affected Growth of Sorghum Intercropped with Cowpea in Different Locations of Western Sudan.

Abstract:

Place and duration of study: Farmers practice different cropping systems with different cultural practice to increase productivity and sustainability. Field experiments were conducted in two locations (Elfoula and Babanousa), Western Kordofan (Sudan), seasons 2011/ 2012 and 2012/ 2013.

Aim: To determine the effect of soil water conservations methods on vegetative growth of sorghum (*Sorghum bicolor* (L.) Moench) intercropped with cowpea (*Vigna unguicualata* (L.) Walp).

Study design: The experimental design was split plot with three replications.

Methodology: The main plots were assigned for four soil conservation methods namely; Geria (main local method of plough used) (L_1) and Geria with terrace (L_2), animal plough (L_3) and animal plough with terrace (L_4) .The sub plots was four sowing methods as follows: Sorghum mono crop (S_1), Sorghum intercrop (S_2), Cowpea intercrop (C_1), Cowpea mono crop(C_2).the parameters taken was plant height, stem diameter, leaf area index and dry weight for three 30, 45 and 60 days from sowing dates.

Results: Generally, the soil preparation with animal traction and terrace (L_4) and sorghum mono crop and their interaction showed the highest plant height, stem diameter, leaf area index, and dry weight products followed with soil prepared with Geria and terrace for two locations and two seasons.

***Key words*:** soil water conservation methods, sorghum, cowpea, intercrop, locations.

Introduction:

Rain fed agriculture is a potential key to food production in semi- arid areas. Low productivity of rain fed sorghum in Western Sudan as by (Agric. report) and also low cowpea grain and fodder yield are very low in West Africa and Sudan as pointed by [1]. The low yield is due to uncertain and uneven distribution of rains, poor cultural practice, and low yielding varieties and dry spell and moisture deficit, although water management is a key for agriculture production in dry areas [2]. Therefore, water conservation techniques and deep tillage are used to improve soil moisture capacity by increasing soil porosity to capture the rain water this increase the availability, in addition run off is reduced through increased roughness of soil surface this increase the availability of water to root zone and assist better plant growth [2] and to high variable rainfall, of dry spells and recurrent droughts. Water management is a key for agriculture production in dry areas [2].

Intercropping is a simultaneous growing of two or more crops in the same field [3]. The practice of growing sorghum and cowpea on the same piece of land is one of the most important cropping systems. Reasons of intercropping vary depending on individual farmer production goals. Yield of intercropping are often higher than in sole cropping systems because resources like water, light and nutrients can be utilized more effectively than in sole cropping systems [4]

This area lies in Southern Sudan which suffers from civil war and different climatic change. Traditional methods of cultivation were applied and no research was done in this area. This study aimed to highlight the effect of different land preparations by using local instrument Geria and animal traction plough and terrace and determined the effect of these approaches on vegetative growth sorghum, *Sorghum bicolor* (L. Moench) intercropped with cowpea *Vigna ungiculata (*L. Walp) under two locations Elfola and Babanosa in Western Sudan (Kordofan State).

Material and methods:

Experimental site, climatic and soil factors:

This study was carried out in two consecutive summer seasons 2011/ 12- 2012/13, in two locations of Western Sudan (ElFoula and Babanousa,) Lat. 9°.$^{20-}$N and Long. 27°.3^{-} E). The climate of the locality lies at the border of the savannah belt (Agric. Report, 2014). The rainy season extends from May to October; with average rainfall 400- 650 mm) and the soil is loamy to sandy clay in the south.

Land preparation:

The experimented site was clear from grasses and previous crops residues. The experimented area was then plough with Geria (local instrument used for plough) and animal traction also the Geria plough and animal traction half of it was terrace and the other half without terrace.

Experimental design and treatment:

The experimental design was split plot with three replications. The main plots were assigned for L_1 and L_2 Geria with terrace, L_3 of plough and L_4 animal plough with terrace. The plots are 5×5 m, the plant spaces at 60 and 40 cm apart, between rows and within row respectively. The experimental unit was separated by 50 cm from each other and 2cm between replications. The crop sowing methods as follows: S_1 = Sorghum mono crop, S_2 = Sorghum intercrop, C_1 = Cowpea intercrop, C_2 = Cowpea mono crop

The seed rate was 7.5 kg and 19 kg/ha for sorghum(Zanrie) and cowpea respectively. The crops were sown at the first week of July for the two seasons. Three weeks after sowing thinning was done. The experiment received three hands weeding during each of the two growing seasons and for the two locations. The insecticide Sevien 85% was used three weeks after sowing, to protect sorghum crop from stem borer than Malathione 75 % was used mainly after cowpea flowering and bud setting to control flee beetle and bugs and it was serve during the second into the two locations.

Data collection:

In the two locations and for two seasons, samples from the crops were taken from the outer lines of each plot. The samples were taken for plants at 30, 45 and 60 days old for the following determinations:, Plant height in (cm) The plant height was measured of five plant randomly selected at each treatment, measured from the base of the plant up to tip (cm), stem diameter stem diameter of the five plant was measured using Venire Claipel, leaf area index leaf area index was measured as follows for sorghum crops: Length of the fourth leaf × maximum width x Leaf number× 0.75. And leaf area of cowpea was measured and calculated as follows: Tip leaf length× maximum width x Leaf number× 0.624. The fresh weight of half of the line was for three sampling occasions (30, 45 and 60 days after sowing). A sensitive balance were used for weighing, then the dry weight was determined from a sub- sample of 300 g from each fresh weight of sample and sensitive balance was used to determine the dry weight then expressed in (t/ha).

Data analysis

The data collected in the two seasons was analyzed using statistical analyses for split design according to [5]. The mean were compared according to Duncan's Rang Test (DMRT) at P=0.05. Sample of the millet grain from each plot selected and taken to the chemistry laboratory and nutritional elements were determined for the two seasons.

Results and discussion:

The effect of soil water conservation methods on plant height in Elfoula and location for two seasons during 30, 45, and 60 days of growing was presented in Table 1a-1b. The results had shown a highly significant difference among land preparation methods and cropping systems except in 60 days of second season. L4 and S1xL4 had the highest plant height. Intercropping of sorghum and cowpea were significant at 45 and 60days of first season and C1 showed the highest value. For the second season, 45 days obtained significant difference and S1 showed the highest plant height. in

Babanousa location plant height results showed in Table 2a-2b with highly significant difference for all results. Land preparation methods inconsistent with Elfoula methods and L4 had the higher plant height for all treatments. But S1 and L4x S1 had the highest plant height for all results.

Table 1a. The effect of soil water conservation methods on plant height (cm) of sorghum intercropped with cowpea in ELfuola season 2011/12:

Day after sowing	30 days					45 days					60 days				
Treatment	S_1	S_2	C_1	C_2	X	S_1	S_2	C_1	C_2	X	S_1	S_2	C_1	C_2	X
Land preparation															
L_1	33.8^{ab}	30.4^{ab}	31.2^{ab}	27.4^{b}	30.2^{b}	51.2^{ab}	48.3^{ab}	48.1^{ab}	54.1^{ab}	50.4^{b}	80.8^{bc}	75.2^{c}	90.7^{abc}	92.2^{abc}	84.7^{c}
L_2	40.6^{a}	36.3^{ab}	39.3^{ab}	31.9^{ab}	37.02^{a}	54.5^{ab}	53.9^{ab}	52.4^{ab}	59.8^{ab}	55.2^{ab}	101.5^{ab}	92.4^{abc}	98.6^{abc}	105.5^{a}	99.6^{ab}
L_3	36.5^{ab}	31.5^{ab}	37.6^{ab}	33.8^{ab}	34.9^{ab}	53.1^{ab}	52.1^{ab}	47.2^{b}	54.2^{ab}	51.7^{ab}	101.6^{ab}	81.5^{bc}	93.3^{abc}	93.5^{abc}	91.7^{bc}
L_4	40.4^{a}	37.9^{ab}	41.0^{a}	36.5^{ab}	39.55^{a}	64.2^{ab}	59.9^{ab}	50.4^{ab}	65.9^{a}	60.1^{a}	107.5^{a}	98.1^{abc}	104.0^{ab}	105.6^{a}	103.9^{a}
X	37.9^{a}	34.1^{a}	37.3^{a}	32.4^{a}		55.8^{ab}	53.6^{ab}	49.5^{b}	58.5^{a}		97.96^{ab}	86.8^{b}	95.9^{ab}	99.5^{a}	
CV%					21.3					19.81					14.92
LSD_C					3.0764					4.3957					4.59
LSD_L					3.0674.					4.3957					4.59
LSD_{CXL}					6.2829					8.7914					8.18

Table 1b. The effect of soil water conservation methods on plant height (cm)of sorghum intercropped with cowpea in ELfuola season 2012/13:

L_1	47.5^{cde}	46.3^{def}	42.3^{def}	40.1^{ef}	44.1^{b}	89.4^{ef}	85.0^{f}	87.1^{ef}	91.5^{ef}	88.2^{c}	208.5^{a}	171.7^{a}	193.2^{a}	202.5^{a}	193.9^{a}
L_2	55.8^{ab}	49.3^{bcd}	42.6^{def}	42.8^{def}	47.6^{ab}	101.2^{bcde}	97.1^{cdef}	93.1^{cdef}	101.9^{bcd}	98.3^{b}	198.5^{a}	186.5^{a}	202.1^{a}	193.3^{a}	195.1^{a}
L_3	48.9^{bcd}	51.8^{abc}	39.3^{f}	42.2^{def}	45.6^{b}	98.5^{cdef}	87.1^{def}	86.1^{ef}	91.7^{def}	90.8^{bc}	183.2^{a}	181.7^{a}	202.9^{a}	215.2^{a}	195.8^{a}
L_4	50.9^{a}	56.2^{ab}	45.8^{cdef}	44.2^{cdef}	51.3^{a}	124.1^{a}	116.2^{ab}	99.0^{cdef}	107.6^{bc}	111.7^{a}	214.9^{a}	207.4^{a}	183.1^{a}	222.4^{a}	206.9^{a}
X	52.8^{a}	50.9^{a}	42.5^{a}	42.9^{a}		103.3^{a}	96.3^{ab}	91.3^{b}	98.2^{ab}		201.3^{a}	186.8^{a}	195.3^{a}	208.4^{a}	
CV%					10.2					9.6					16.6
LSD_C					1.97					3.81					12.163
LSD_L					1.97					3.81					12.163
LSD_{CXL}					3.93					7.61					24.327

L_1 Geria, L_2 Geria with terrace, L_3 animal plough and L_4 animal plough with terrace. S_1 Sorghum mono crop,S_2 Sorghum intercrop,C_1 Cowpea intercrop, C_2 = Cowpea mono crop. Means followed by different letters are significantly at $p < 0.05$ (Duncant test).

Table 2a. The effect of soil water conservation methods on plant height of sorghum intercrop with cowpea in Babanousa season 2011/12:

Day after sowing	30 days					45 days					60 days				
Treatment Land preparation	S_1	S_2	C_1	C_2	X	S_1	S_2	C_1	C_2	X	S_1	S_2	C_1	C_2	X
L_1	79.7^{bc}	67.6^{c}	40.2^{d}	42.9^{d}	56.4c	112.1^{bc}	104.3^{cd}	79.97^{g}	85.0^{fg}	95.3^{c}	191.8^{abc}	168.8^{bcd}	128.7^{e}	132.0^{de}	155.3^{c}
L_2	84.3^{ab}	80.2^{bc}	42.4^{d}	45.1^{d}	63.7^{a}	125.8^{a}	122.9^{ab}	97.4^{def}	100.8^{cde}	111.8^{a}	212.0^{a}	209.5^{a}	141.0^{e}	136.9^{de}	174.9^{ab}
L_3	80.1^{bc}	77.7^{bc}	40.6^{d}	44.5^{d}	60.7^{b}	122.6^{ab}	120.3^{ab}	82.3^{g}	88.97^{efg}	103.5^{b}	211.4^{a}	204.0^{ab}	126.6^{e}	130.6^{e}	168.2bc
L_4	95.6^{a}	86.3^{ab}	45.7^{d}	48.6^{d}	69.3^{b}	131.97^{a}	128.8^{a}	98.0^{def}	102.97^{cd}	115.4^{a}	225.6^{a}	217.8^{a}	149.1^{de}	160.8^{cde}	188.3^{a}
X	83.7^{a}	77.9^{a}	42.4^{b}	46.1^{b}		123.1^{a}	119.1^{a}	89.2^{b}	94.6^{b}		210.2^{a}	200.0^{a}	136.4^{b}	140.1^{b}	
CV%					12.53					7.00					10.85
LSD_C					3.2					3.04					9.1
LSD_L					3.2					3.04					9.1
LSD_{CXL}					6.4					6.1					18.2

Table 2 b. The effect of soil water conservation methods on plant height of sorghum intercrop with cowpea in Babanousa season 2012/13:

L_1	43.8^{abc}	39.8^{c}	43.8^{abc}	42.1^{bc}	42.4^{b}	93.9^{ef}	99.3^{bcdef}	90.3^{f}	84.9^{f}	92.1^{c}	191.3^{bc}	183.2^{c}	186.9^{c}	193.7^{abc}	188.8^{b}
L_2	44.8^{ab}	42.0^{bc}	43.4^{bc}	41.8^{bc}	42.99^{ab}	114.7^{ab}	106.8^{abcde}	95.6^{def}	100.1^{bcdef}	104.3^{ab}	212.7^{ab}	204.8^{abc}	189.4^{bc}	198.0^{abc}	201.2^{a}
L_3	43.7^{abc}	41.3^{bc}	44.1^{abc}	43.4^{bc}	43.1^{ab}	110.4^{abcd}	109.8^{abcd}	95.6^{def}	94.4^{ef}	102.5^{b}	206.6^{abc}	201.3^{abc}	189.7^{bc}	197.3^{abc}	198.7^{b}
L_4	47.9^{a}	45.1^{ab}	43.3^{bc}	43.4^{bc}	44.9^{a}	120.1^{a}	119.1^{a}	96.3^{cdef}	111.3^{abc}	111.7^{a}	216.8^{a}	211.9^{ab}	200.7abc	202.8^{abc}	207.9^{a}
X	45.12^{a}	43.6^{ab}	42.7^{b}	42.0^{b}		109.8^{a}	108.8^{a}	97.7^{a}	94.4^{b}		206.8^{a}	200.3^{ab}	191.5^{b}	197.95^{ab}	
CV%					6.06					7.27					12.28
LSD_C					1.1					3.8					5.91
LSD_L					1.1					3.8					5.91
LSD_{CXL}					2.14					7.5					11.82

L_1 Geria, L_2 Geria with terrace, L_3 animal plough and L_4 animal plough with terrace. S_1 Sorghum mono crop,S_2 Sorghum intercrop,C_1 Cowpea intercrop, C_2 = Cowpea mono crop. Means followed by different letters are significantly at $p < 0.05$ (Duncant test).

Stem diameter of sorghum and cowpea as affected by soil water conservation methods and intercropping were presented in Table 3a-3b and 4a-4b for two locations for two seasons. In general S1and S2 (mono sorghum and intercopped sorghum with cowpea), L4 and L4xS2 showed the thickest stem diameter with highly significant difference for all treatments during 30,45 and 60 days of growth for two locations and two seasons.

Table 3a. The effect of soil water conservation method on stem diameter of sorghum (cm) intercrop with cowpea in ELfoula season 2011/13:

Day after sowing	**30 days**					**45 days**					**60 days**				
Treatment Land preparation	S_1	S_2	C_1	C_2	X	S_1	S_2	C_1	C_2	X	S_1	S_2	C_1	C_2	X
L_1	1.26^{b}	1.36^{b}	0.73^{e}	0.77^{e}	1.1^{b}	2.34^{b}	2.46^{ab}	0.90^{d}	1.20^{cd}	1.72^{ab}	2.47	2.53^{c}	0.98^{h}	1.28^{fgh}	1.81^{c}
L_2	1.47^{b}	1.72^{a}	0.79^{c}	0.89^{e}	1.2^{a}	2.60^{ab}	2.81^{a}	0.96^{d}	1.56^{c}	1.98^{a}	2.71	3.00^{abc}	1.07^{fgh}	1.65^{de}	2.11^{ab}
L_3	1.28^{b}	1.33^{b}	0.73^{e}	0.84^{e}	1.0^{b}	2.53^{ab}	2.63^{ab}	0.93^{d}	1.20^{cd}	1.82^{ab}	2.57	2.78^{abc}	1.01^{fgh}	1.37^{efg}	1.93^{be}
L_4	1.73^{a}	1.78^{a}	0.81^{c}	0.97^{e}	1.3^{a}	2.96^{ab}	2.88^{a}	0.96^{d}	1.56^{e}	2.02^{a}	2.85	3.03^{a}	1.40^{ef}	1.77^{d}	2.27^{a}
X	1.4^{a}	1.5^{a}	0.76^{b}	0.86^{b}		2.53^{a}	2.69^{a}	0.94^{b}	1.38^{b}		2.65^{b}	2.83^{a}	1.12^{d}	1.56^{c}	
CV%					12.84					14.06					10.87
LSD_C					0.123					0.221					0.184
LSD_L					0.123					0.221					0.184
LSD_{CXL}					0.246					0.442					0.368

Table 3 b. The effect of soil water conservation method on stem diameter of sorghum (cm) intercrop with cowpea in ELfoula season 2012/2013:

L_1	1.02^{bcd}	1.11^{bc}	0.72^{de}	0.71^{cd}	0.89^{bc}	1.50^{de}	1.56^{cd}	0.95^{fg}	0.93^{fg}	1.23^{c}	1.78^{e}	1.83^{be}	1.15^{d}	1.14^{d}	1.47^{b}
L_2	1.25^{b}	0.44^{d}	0.80^{cd}	0.85^{ed}	0.83^{c}	1.75^{bcd}	1.81^{abc}	1.01^{fg}	1.13^{fg}	1.43^{b}	1.92^{bc}	1.99^{abc}	1.11^{d}	1.27^{d}	1.58^{ab}
L_3	1.26^{b}	1.257^{b}	0.78^{d}	0.84^{ed}	1.03^{b}	1.79^{abc}	1.82^{abc}	0.97^{fg}	1.10^{fg}	1.42^{b}	1.91^{be}	2.02^{ab}	1.17^{d}	1.21^{d}	1.58^{ab}
L_4	1.63^{a}	1.75^{a}	0.79^{cd}	0.84^{ed}	1.26^{a}	1.87^{ab}	2.05^{a}	1.18^{fg}	1.22^{fg}	1.58^{a}	2.04^{ab}	2.17^{a}	1.21^{d}	1.33^{d}	1.69^{a}
X	1.29^{a}	1.14^{a}	0.77^{b}	0.81^{b}		1.73^{a}	1.82^{a}	1.03^{b}	1.09^{b}		1.91^{a}	2.00^{a}	1.16^{b}	1.24^{b}	
CV%					19.34					12.16					9.20
LSD_C					0.162					0.143					0.121
LSD_L					0.162					0.143					0.121

LSD_{CXL}	0.323	0.286	0.242

L_1 Geria, L_2 Geria with terrace, L_3 animal plough and L_4 animal plough with terrace. S_1 Sorghum mono crop,S_2 Sorghum intercrop,C_1 Cowpea intercrop, C_2 = Cowpea mono crop. Means followed by different letters are significantly at $p < 0.05$ (Duncant test).

Table 4 a. The effect of soil water conservation methods on stem diameter of sorghum (cm) intercrop with cowpea in Babanousa season 2011/12:

Day after sowing			**30 days**					**45 days**					**60 days**		
Treatment Land preparation	S_1	S_2	C_1	C_2	X	S_1	S_2	C_1	C_2	X	S_1	S_2	C_1	C_2	X
L_1	1.26^{b}	1.30^{b}	0.73^{c}	0.77^{c}	1.02^{b}	2.34^{c}	2.45^{be}	0.90^{e}	1.20^{de}	1.72^{c}	2.46^{e}	2.53^{bc}	0.98^{h}	1.28^{fgh}	1.81^{c}
L_2	1.47^{b}	1.73^{a}	0.79^{c}	0.89^{c}	1.22^{a}	2.60^{abc}	2.81^{ab}	0.96^{e}	1.56^{d}	1.98^{ab}	2.70^{abc}	3.00^{a}	1.07^{fgh}	1.65^{de}	2.11^{ab}
L_3	1.28^{b}	1.33^{b}	0.74^{c}	0.84^{c}	1.05^{b}	2.41^{be}	2.63^{abc}	0.93^{e}	1.20^{de}	1.79^{bc}	2.57^{bc}	2.78^{abc}	1.01^{gh}	1.37^{efg}	1.93^{bc}
L_4	1.73^{a}	1.78^{a}	0.81^{c}	0.96^{c}	1.32^{a}	2.69^{abc}	2.88^{a}	0.96^{e}	1.56^{d}	2.02^{a}	2.85^{ab}	3.03^{a}	1.40^{ef}	1.77^{d}	2.27^{a}
X	1.43^{a}	1.53^{a}	0.77^{b}	0.87^{b}		2.51^{a}	2.69^{a}	0.94^{c}	1.38^{b}		2.65^{b}	2.83^{a}	1.12^{d}	1.52^{c}	
CV%					12.91					13.71					10.85
LSD_C					0.124					0.215					0.184
LSD_L					0.124					0.215					0.184
LSD_{CXL}					0.247					0.430					0.3671

Table 4 b. The effect of soil water conservation methods on stem diameter of sorghum (cm) intercrop with cowpea in Babanousa season 2012/13:

L_1	1.60^{c}	1.68^{be}	0.85^{d}	0.81^{d}	1.24^{b}	2.02^{b}	2.08^{b}	1.10^{ed}	0.95^{cd}	1.54^{bc}	2.00^{c}	2.21^{bc}	1.43^{ef}	1.58^{de}	1.81^{b}
L_2	1.69^{abc}	1.80^{ab}	0.86^{d}	0.89^{d}	1.31^{a}	2.20^{ab}	2.35^{a}	1.01^{cd}	1.04^{cd}	1.65^{ab}	2.35^{ab}	2.34^{ab}	1.26^{f}	1.61^{de}	1.89^{ab}
L_3	1.71^{abc}	1.72^{abc}	0.85^{d}	0.86^{d}	1.28^{ab}	2.04^{b}	2.09^{b}	0.97^{cd}	1.03^{cd}	1.53^{c}	2.22^{be}	2.31^{ab}	1.31^{f}	1.58^{de}	1.85^{ab}
L_4	1.75^{ab}	1.82^{a}	0.77^{d}	0.88^{d}	1.31^{a}	2.18^{ab}	2.34^{a}	0.92^{d}	1.17^{c}	1.65^{a}	2.34^{ab}	2.47^{a}	1.26^{f}	1.69^{d}	1.96^{a}
X	1.69^{b}	1.76^{a}	0.83^{c}	0.86^{c}		2.11^{a}	2.21^{a}	1.00^{b}	1.05^{b}		2.25^{a}	2.33^{a}	1.32^{c}	1.61^{b}	
CV%					6.24					8.76					7.41
LSD_C					0.067					0.116					0.115
LSD_L					0.067					0.116					0.115

LSD_{CXL}	0.134	0.233	0.232

L_1 Geria, L_2 Geria with terrace, L_3 animal plough and L_4 animal plough with terrace. S_1 Sorghum mono crop,S_2 Sorghum intercrop,C_1 Cowpea intercrop, C_2 = Cowpea mono crop. Means followed by different letters are significantly at $p < 0.05$ (Duncant test).

Leaf area index values were obtained in Table 5a-5b and 6a-6b, the results indicated that S1(mono sorghum), L4(animal plough with terrace) and their interaction had the highest values with highly significant difference among all treatments for two seasons and two locations, with 30, 45 and 60 days of growth.

Table 5 a. The effect of soil water conservation method on leaf area index of sorghum intercrop with cowpea ELfoula season 2011/12

Day after sowing	**30 days**					**45 days**					**60 days**				
Treatment Land preparation	S_1	S_2	C_1	C_2	X	S_1	S_2	C_1	C_2	X	S_1	S_2	C_1	C_2	X
L_1	1.8^{be}	1.4^{e}	0.28^{d}	0.26^{d}	0.94^{b}	3.2^{b}	3.1^{b}	0.51^{e}	0.42^{c}	1.8^{b}	4.1^{e}	4.0^{c}	0.47^{d}	0.65^{d}	2.3^{e}
L_2	2.3^{ab}	1.8^{be}	0.39^{d}	0.27^{d}	1.2^{ab}	4.6^{a}	3.6^{ab}	0.27^{e}	0.53^{c}	2.3^{ab}	5.2^{b}	4.9^{b}	0.52^{d}	0.70^{d}	2.8^{b}
L_3	1.9^{be}	1.8^{be}	0.36^{d}	0.27^{d}	1.1^{ab}	3.2^{b}	3.1^{b}	0.39^{c}	0.45^{c}	1.8^{b}	4.8^{b}	4.5^{b}	0.45^{d}	0.56^{d}	2.6^{bc}
L_4	2.7^{a}	1.97^{be}	0.42^{d}	0.32^{d}	1.4^{a}	4.7^{a}	4.0^{ab}	0.53^{e}	0.66^{c}	2.5^{a}	6.5^{a}	5.0^{a}	0.61^{d}	0.71^{d}	3.2^{a}
X	2.2^{a}	1.8^{b}	0.40^{c}	0.30^{c}		3.9^{a}	3.4^{a}	0.50^{b}	0.52^{b}		5.1^{a}	4.6^{b}	0.52^{e}	0.66^{e}	
CV%					30.76					33.96					14.80
LSD_C					0.2921					0.593					0.337
LSD_L					0.2921					0.593					0.337
LSD_{CXL}					0.5842					1.18					0.675

Table 5 b. The effect of soil water conservation method on leaf area index of sorghum intercrop with cowpea ELfoula season 2012/13:

L_1	2.96^{de}	2.59^{e}	0.327^{f}	0.284^{f}	1.54^{c}	4.59^{be}	4.01^{c}	0.28^{d}	0.27^{d}	2.29^{b}	4.91^{c}	4.77^{c}	0.32^{d}	0.317^{d}	2.58^{c}
L_2	3.363^{cd}	2.911^{de}	0.339^{f}	0.315^{f}	1.73^{bc}	5.44^{ab}	4.91^{abe}	0.36^{d}	0.35^{d}	2.79^{ab}	5.92^{ab}	5.29^{ab}	0.36^{d}	0.362^{d}	2.98^{ab}
L_3	3.79^{be}	3.56^{cd}	0.307^{f}	0.324^{f}	1.99^{b}	4.62^{b}	4.50^{bc}	0.29^{d}	0.32^{d}	2.43^{b}	5.32^{bc}	4.84^{bc}	0.38^{d}	0.35^{d}	2.72^{bc}
L_4	4.55^{a}	4.37^{ab}	0.317^{f}	0.357^{f}	2.40^{a}	5.88^{a}	5.78^{a}	0.43^{d}	0.40^{d}	3.12^{a}	6.42^{a}	5.93^{ab}	0.358^{d}	0.37^{d}	3.27^{a}
X	3.67^{a}	3.36^{a}	0.322^{b}	0.320^{b}		5.16^{a}	4.8^{a}	0.34^{b}	0.33^{b}		5.64^{a}	5.22^{b}	0.353^{c}	0.347^{c}	
CV%					20.88					26.26					19.34

LSD_C	0.334	0.581	0.386
LSD_L	0.334	0.581	0.386
LSD_{CXL}	0.668	1.164	0.771

L_1 Geria, L_2 Geria with terrace, L_3 animal plough and L_4 animal plough with terrace. S_1 Sorghum mono crop,S_2 Sorghum intercrop,C_1 Cowpea intercrop, C_2 = Cowpea mono crop. Means followed by different letters are significantly at $p < 0.05$ (Duncant test).

Table 6 a. The effect of soil water conservation methods on leaf area index of sorghum intercrop with cowpea Babanousa season 2011/12:

Day after sowing					**30 days**					**45 days**					**60 days**
Treatment Land preparation	S_1	S_2	C_1	C_2	X	S_1	S_2	C_1	C_2	X	S_1	S_2	C_1	C_2	X
L_1	2.45^{b}	2.39^{b}	0.29^{c}	0.41^{c}	1.38^{b}	4.73^{cde}	4.23^{c}	0.36^{f}	0.46^{f}	2.44^{c}	5.37^{bc}	4.97^{c}	0.37^{d}	0.50^{d}	2.81^{b}
L_2	3.51^{a}	2.86^{ab}	0.31^{c}	0.48^{c}	1.79^{ab}	5.66^{ab}	5.15^{bcd}	0.47^{f}	0.52^{f}	2.95^{ab}	4.98^{ab}	5.46^{bc}	0.52^{d}	0.54^{d}	3.13^{b}
L_3	2.76^{ab}	2.81^{ab}	0.39^{c}	0.42^{c}	1.59^{ab}	5.14^{bcd}	4.37^{de}	0.43^{f}	0.42^{f}	2.59^{bc}	5.42^{bc}	5.67^{bc}	0.47^{d}	0.47^{d}	3.01^{b}
L_4	3.52^{a}	2.87^{ab}	0.56^{c}	0.61^{c}	1.89^{a}	6.38^{a}	5.42^{be}	0.56^{f}	0.65^{f}	3.25^{a}	6.79^{a}	5.79^{b}	0.77^{d}	0.86^{d}	3.55^{a}
X	3.06^{a}	2.73^{a}	0.39^{b}	0.48^{b}		5.477^{a}	4.79^{b}	0.45^{e}	0.51^{c}		5.89^{a}	5.47^{b}	0.53^{c}	0.60^{c}	
CV%					30.12					17.35					15.44
LSD_C					0.419					0.437					0.402
LSD_L					0.419					0.437					0.402
LSD_{CXL}					0.836					0.874					0.804

Table 6 b. The effect of soil water conservation methods on leaf area index of sorghum intercrop with cowpea Babanousa season 2012/13:

Day after sowing					**30 days**					**45 days**					**60 days**
Treatment Land preparation	S_1	S_2	C_1	C_2	X	S_1	S_2	C_1	C_2	X	S_1	S_2	C_1	C_2	X
L_1	2.99^{ab}	2.82^{b}	0.25^{c}	0.28^{c}	1.58^{a}	4.00^{b}	3.64^{b}	0.32^{c}	0.30^{c}	2.06^{b}	6.03^{e}	6.11^{de}	0.39^{f}	0.39^{f}	3.23^{b}
L_2	3.05^{ab}	2.97^{ab}	0.22^{c}	0.29^{c}	1.63^{a}	4.79^{a}	4.61^{a}	0.33^{c}	0.38^{c}	2.52^{a}	7.57^{ab}	6.85^{bcd}	0.37^{f}	0.39^{f}	3.79^{a}
L_3	2.99^{ab}	2.87^{b}	0.24^{c}	0.30^{c}	1.60^{a}	4.49^{a}	4.48^{a}	0.33^{c}	0.37^{c}	2.42^{a}	7.13^{abc}	6.73^{cde}	0.34^{f}	0.39^{f}	3.65^{a}
L_4	3.53^{ab}	3.27^{ab}	0.21^{c}	0.31^{c}	1.83^{a}	4.95^{a}	4.77^{a}	0.32^{c}	0.40^{c}	2.61^{a}	7.72^{a}	6.90^{bc}	0.34^{f}	0.46^{f}	3.85^{a}

X	3.14[a]	2.98[a]	0.23[b]	0.30[b]		4.56[a]	4.37[a]	0.32[b]	0.36[b]		7.11[a]	6.65[b]	0.36[c]	0.41[c]	
CV%					22.14					11.89					12.28
LSD_C					0.307					0.238					0.372
LSD_L					0.307					0.238					0.342
LSD_{CXL}					0.613					0.477					0.744

L_1 Geria, L_2 Geria with terrace, L_3 animal plough and L_4 animal plough with terrace. S_1 Sorghum mono crop,S_2 Sorghum intercrop,C_1 Cowpea intercrop, C_2 = Cowpea mono crop. Means followed by different letters are significantly at $p < 0.05$ (Duncant test).

Table 7a-7b and 8a-8b showed the dry weight of sorghum intercropped with cowpea. The results showed highly significant difference for two seasons with different growing days (30, 45 and 60 days) for two locations. As above results S1, L4 and S1xL4 had the highest dry weight.

Table 7 a. The effect of soil water conservation methods on dry weight of sorghum (g) intercrop with cowpea in ELfoula season 2011/12:

Day after sowing	**30 days**					**45 days**					**60 days**				
Treatment	S_1	S_2	C_1	C_2	X	S_1	S_2	C_1	C_2	X	S_1	S_2	C_1	C_2	X
Land preparation															
L_1	1.41[cd]	1.21[d]	0.34[f]	0.39[f]	0.84[c]	1.90[de]	1.60[efg]	0.77[h]	1.43[g]	1.42[c]	3.03[ed]	2.51[e]	1.44[gh]	1.75[fg]	2.18[b]
L_2	1.87[ab]	1.62[bc]	0.40[f]	0.59[ef]	1.12[ab]	2.91[ab]	2.65[bc]	0.87[h]	1.56[efg]	1.99[b]	3.47[abe]	3.17[bcd]	1.34[gh]	1.99[f]	2.50[a]
L_3	1.70[bc]	1.50[cd]	0.41[f]	0.43[ef]	1.01[b]	2.68[b]	2.26[cd]	0.80[h]	1.48[fg]	1.81[b]	3.16[bed]	2.99[d]	1.37[gh]	1.95[f]	2.37[ab]
L_4	2.05[a]	1.91[ab]	0.34[f]	0.74[e]	1.26[a]	3.27[a]	3.19[a]	0.80[h]	1.86[ef]	2.28[a]	3.71[a]	3.53[ab]	1.08[h]	2.06[ef]	2.60[a]
X	1.76[a]	1.56[b]	0.37[d]	0.54[c]		2.69[a]	2.43[b]	0.81[d]	1.58[c]		3.34[a]	3.05[b]	1.32[d]	1.94[c]	
CV%					18.63					12.49					11.63
LSD_C					0.164					0.195					0.233
LSD_L					0.164					0.195					0.233
LSD_{CXL}					0.328					0.391					0.467

Table 7 b. The effect of soil water conservation methods on dry weight of sorghum (g) intercrop with cowpea in ELfoula season 2012/13:

L_1	0.30^{b}	0.26^{bc}	0.13^{cd}	0.11^{cd}	0.20^{b}	0.82^{bcd}	0.69^{abcde}	0.49^{cde}	0.79^{abcd}	0.70^{a}	1.50^{cde}	1.07^{defg}	0.72^{efg}	1.31^{cdef}	1.15^{b}
L_2	0.39^{b}	0.59^{a}	0.07^{d}	0.10^{cd}	0.29^{a}	1.16^{a}	0.91^{abcd}	0.44^{de}	0.70^{abcde}	0.80^{a}	2.01^{abe}	1.76^{bcd}	0.54^{fg}	1.24^{cdef}	1.39^{ab}
L_3	0.36^{b}	0.30^{b}	0.11^{cd}	0.13^{cd}	0.22^{ab}	1.05^{ab}	0.63^{bcde}	0.50^{cde}	0.79^{abcd}	0.74^{a}	1.52^{cde}	1.34^{cdef}	0.59^{fg}	1.28^{cdef}	1.18^{b}
L_4	0.43^{ab}	0.38^{b}	0.06^{c}	0.09^{d}	0.24^{ab}	1.01^{ab}	0.95^{abc}	0.22^{e}	0.77^{abed}	0.74^{a}	2.36^{ab}	2.72^{a}	0.35^{g}	1.33cdef	1.69^{a}
X	0.37^{a}	0.38^{a}	0.09^{b}	0.11^{b}		1.01^{a}	0.79^{a}	0.41^{b}	0.76^{a}		1.85^{a}	1.72^{a}	0.55^{c}	1.29^{b}	
CV%					42.07					40.70					36.15
LSD_C					0.083					0.253					0.408
LSD_L					0.083					0.253					0.408
LSD_{CXL}					0.166					0.505					0.816

L_1 Geria, L_2 Geria with terrace, L_3 animal plough and L_4 animal plough with terrace. S_1 Sorghum mono crop,S_2 Sorghum intercrop,C_1 Cowpea intercrop, C_2 = Cowpea mono crop. Means followed by different letters are significantly at $p < 0.05$ (Duncant test).

Table 8 a. The effect of soil water conservation methods on dry weight of sorghum (g) intercrop with cowpea in Babanousa season 2011/12

Day after sowing			**30 days**					**45 days**					**60 days**		
Treatment	S_1	S_2	C_1	C_2	X	S_1	S_2	C_1	C_2	X	S_1	S_2	C_1	C_2	X
Land preparation															
L_1	1.09^{bcd}	0.98^{cd}	0.26^{h}	0.44^{gh}	0.49^{b}	2.74^{cd}	2.46^{d}	0.58^{e}	0.56^{e}	1.58^{c}	4.59^{e}	4.78^{cd}	1.10^{i}	2.41^{efg}	3.29^{c}
L_2	1.32^{ab}	1.22^{abc}	0.26^{h}	0.51^{fg}	0.83^{a}	3.43^{b}	3.22^{bc}	0.58^{e}	0.83^{e}	2.01^{ab}	6.74^{ab}	6.25^{ab}	1.19^{ghi}	3.32^{ef}	4.37^{ab}
L_3	1.12^{bcd}	0.94^{de}	0.23^{h}	0.45^{gh}	0.69^{b}	2.98^{bcd}	2.81^{bcd}	0.52^{e}	0.65^{e}	1.74^{bc}	6.58^{ab}	5.88^{bc}	1.13^{hi}	2.34^{fgh}	3.98^{b}
L_4	1.45^{a}	1.26^{ab}	0.22^{h}	0.73^{ef}	0.92^{a}	4.12^{a}	3.39^{b}	0.49^{e}	0.91^{e}	2.26^{a}	7.20^{a}	6.95^{ab}	1.17^{hi}	3.58^{de}	4.72^{a}
X	1.24^{a}	1.10^{b}	0.24^{d}	0.53^{c}		3.31^{a}	2.97^{b}	0.54^{c}	0.74^{c}		6.35^{a}	5.96^{a}	1.15^{c}	2.91^{b}	
CV%					18.23					19.86					18.02
LSD_C					0.119					0.313					0.616
LSD_L					0.119					0.313					0.616
LSD_{CXL}					0.232					0.626					1.233

Table 8 b. The effect of soil water conservation methods on dry weight of sorghum (g) intercrop with cowpea in Babanousa season 2012/13

L_1	0.38^{bcd}	0.37^{bcd}	0.14^{e}	0.15	0.26^{b}	2.72^{abc}	2.57^{c}	0.51^{def}	0.69^{def}	1.62^{b}	4.44^{a}	4.20^{b}	0.83^{e}	1.46^{d}	2.73^{a}
L_2	0.47^{ab}	0.45^{ab}	0.15^{e}	0.24^{de}	0.33^{ab}	2.94^{abc}	2.76^{abc}	0.44^{ef}	0.79^{de}	1.73^{ab}	4.33^{ab}	4.28^{ab}	0.52^{fg}	1.67^{c}	2.70^{a}
L_3	0.40^{bc}	0.39^{bc}	0.18^{e}	0.23^{e}	0.30^{ab}	2.88^{abc}	2.63^{bc}	0.52^{def}	0.64^{def}	1.67^{ab}	4.32^{ab}	4.18^{b}	0.72^{ef}	1.61^{ed}	2.71^{a}
L_4	0.56^{a}	0.43^{ab}	0.12^{e}	0.26^{cde}	0.34^{a}	3.12^{a}	3.08^{ab}	0.31^{e}	0.97^{d}	1.87^{a}	4.25^{ab}	4.15^{b}	0.46^{g}	1.82^{c}	2.67^{a}
X	0.45^{a}	0.4^{a}	0.15^{b}	0.22^{b}		2.92^{a}	2.76^{a}	0.44^{c}	0.77^{a}		4.33^{a}	4.20^{b}	5.63^{d}	1.64	
CV%					28.34					16.43					4.59
LSD_C					0.073					0.237					0.104
LSD_L					0.073					0.237					0.104
LSD_{CXL}					0.146					0.574					0.208

L_1 Geria, L_2 Geria with terrace, L_3 animal plough and L_4 animal plough with terrace. S_1 Sorghum mono crop,S_2 Sorghum intercrop,C_1 Cowpea intercrop, C_2 = Cowpea mono crop. Means followed by different letters are significantly at $p < 0.05$ (Duncant test).

Generally the results showed in Tables (1a- 8b) indicated that soil preparation with animal traction and terrace (L_4) showed high plant height, stem diameter, leaf area index, fresh weight and dry weight products followed with soil prepared with Geria and terrace, this result indicated that the terrace were positive on plant production, although plant sowing sorghum mono crop gave high growth parameter than sorghum intercrop with cowpea except stem diameter. Most researcher believe that the intercropping system is specially beneficial to smallholder farmers in the low input /high-risk environment of the tropics [6]. In agreement with this study [7]found that maize mono crop had the tallest plant height compared with maize intercrop with cowpea. However, the depression in the yield of cereal legumes mixture has been attributed to shading by cereal of the legume [8]. On the other hand [9] reported that plant height, plant dry matter were not significantly affected by cow pea intercropping. In similar with the above result, [10] showed that terrace increase sorghum grain yield owing to reduction in runoff, soil loss and increased availability of moisture and nutrient. Also [11] found that normal ploughing weakens the soil, it seems to reduce erosion by increasing infiltration, ploughing used in combination with contour bech terraces seems to have limited erosion and enhance effectiveness of contour bench terrace management.

Conclusion

The main aims of land preparation are to modify and manipulate the land features and soil properties so as to create a favourable environment for seedling establishment and crop growth. Application of terrace as a method of land preparation in this areas Western of Sudan (two locations , Elfoula and Babanousa) revealed better crops growth. Terrace had the best role for water conservation and prevent water run-off specific in this area all of time subject to different climatic change, unstable rainfall and with long dry spell reflect mainly on the stability of water. In this study mono sorghum had better growth. In general, intercropping increases total productivity per unit area through maximum utilization of land, labour and growth resources. This area suffer from civil war, food security is the main agenda for the government so intercropping achieves some goals for saving foods. The research and development in this field must take into account the practices used by the farming community and the experience gained from previous research.

References

[1] El Naim, A. M. and Jaberedar, A. A. 2010. Effect of plant density and cultivar on growth and yield of cowpea (*Vigna ungniculata* L. Walp) in Kordofan, Sudan, International Journal of current Research 2(1): 142- 147.

[2] Irshah, M., Inone, M., Ashraf, M. and Al Busaidi E. 2007. The management option of water for the development of agriculture in dry areas, Journal of Applied Science 7(11): 1551- 1557.

[3] Legwaila, G.M.,T.K. Marokance, Witness .M., 2012. Effects of intercropping on performance of maize and cowpea in Botswana. International Journal of Agriculture and Forestry, 2(6)307-310.

[4] Sun L. , J.H., F.S. Zhang, X.L. Li, S.C. Yang and Z. Rengel, 2006, Wheat/maize or wheat/soybean strip intercropping I. Yield advantage and interspecific interactions on nutrients. Field Crop Res. 71:123−137.

[5] Gomez KA, Gomez AA (1984) Statistical Procedures for Agricultural Research, 2nd edition, A Wily Inter. Sci. publication. John Wiley and Son, New York

[6] Mutssuo,J.M., Mugwe, J.N. and Mucheru-Muna,M.,2012. Potential role of cereal- legume intercropping systems in integrated with soil fertility management in stallholder farming system of Sub-Sahran Africa. Third RUFORUM Biennial Meeting 24-18 September 2012, Entebbe, Uganda, 1815-1843.

[7] Lemlem, A. 2013. The effect of intercropping maize with cowpea and lablab on crop yield. Herland Journal of Agriculture and food science research vol.2 (5):156-170.

[8] Oseni, T.O., and I.G. Aliyu, 2010 effect of row arrengments on sorghum cowpea intercrops in the semi arid Savanah of Nigeria. 12(1)137-140

[9] Mohammed I.B., O. O. Olufajo, B. B. Singh, S. Miko and S. G. Mohammed. 2008. Growth and development of components of sorghum/ cowpea intercrop in Northern Nigeria. ARPN Journal of Agricultural and Biological Sciencevol.3(3):7-13.

[10] Nalatwadmath, S.K., Rao, M. S. Rama Mohan, Husenappa, V.(2008). Impact of inter-terrace conservation measure on sorghum yield in vertisols of semi arid tropics of South India, Indian Journal of Dry Land Agricultural Research and Development, 23(1):36-41.

[11] Al Ali, Y.,J.Touma, P.Zante, S.Nasri, and J.Abergel, 2008.water and sediment balances of a contour bench terracing system in a semi-arid cultivated zone El Gouazine, Central Tunisia. Hydrological Science –Journal, 53(4)883-892.